JUNE 1957

Journal

AMERICAN WATER WORKS ASSOCIATION

VOL. 49 • NO. 6

The fashion in fission on view at the 2nd EJC Nuclear Congress

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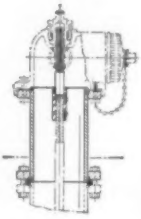

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June 1957

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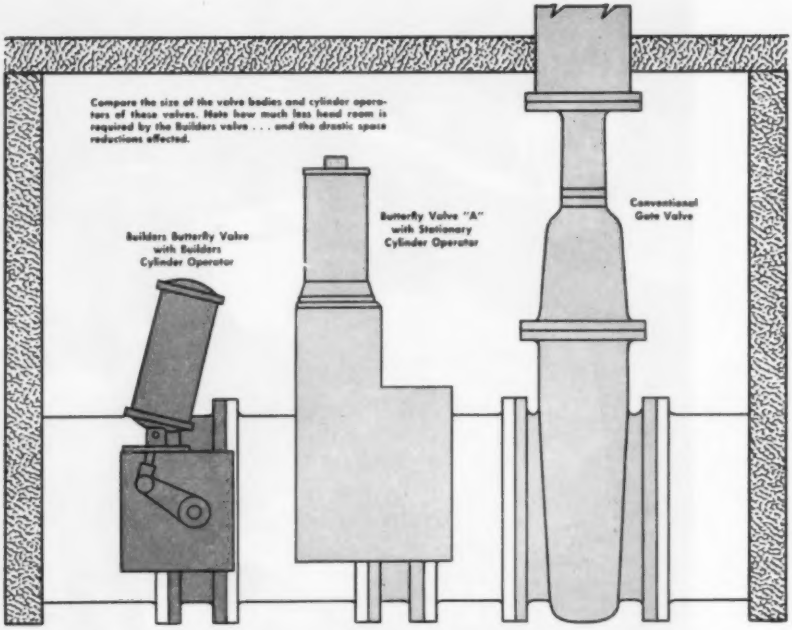
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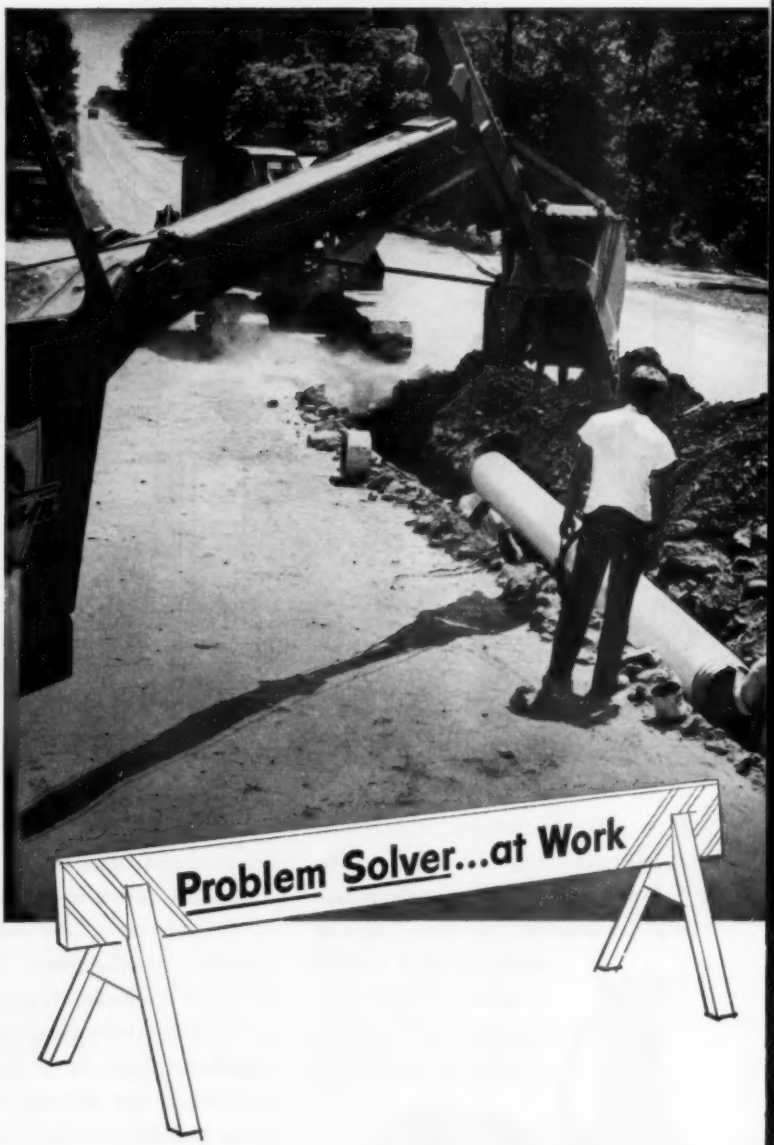

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AWWA SECTIONS

Spring Meetings

Jun. 12–14—Pennsylvania Section, at Bedford Springs Hotel, Bedford Springs. Secretary, L. S. Morgan, Div. Engr., State Dept. of Health, Greensburg.

Jun. 17–19—Canadian Section, at Royal Alexandra Hotel, Winnipeg, Man. Secretary, A. E. Berry, Director, San. Eng. Div., Ontario Dept. of Health, 72 Grenville St., Toronto, Ont.

Fall Meetings

Sep. 4–6—Wisconsin Section, at Hotel Schroeder, Milwaukee. Secretary, Harry Breimeister, Chief Utility Engr., City Engineer's Office, City Hall, Milwaukee 2.

Sep. 11–13—New York Section, at Saranac Inn, Upper Saranac Lake. Secretary, Kimball Blanchard, New York Branch Mgr., Rensselaer Valve Co., c/o Ludlow Valve Co., 11 W. 42nd St., New York.

Sep. 18–20—Ohio Section, at Netherland Plaza Hotel, Cincinnati. Secretary, M. E. Druley, Dist. Mgr., Dayton Power & Light Co., Wilmington.

Sep. 23–25—Kentucky-Tennessee Section, at Brown Hotel, Louisville, Ky. Secretary, J. Wiley Finney Jr., Howard K. Bell, Cons. Engrs., 553 S. Limestone St., Lexington, Ky.

Sep. 24–25—Rocky Mountain Section, at La Fonda Hotel, Santa Fe, N.M. Secretary, J. W. Davis, 301 Continental Oil Bldg., Denver 2, Colo.

Sep. 25–27—Michigan Section, at Leland Hotel, Detroit. Secretary, T. L. Vander Velde, Chief, Sec. of Water Supply, State Dept. of Health, Lansing 4.

Sep. 25–27—North Central Section, at Gardner Hotel, Fargo, N.D. Secretary, L. N. Thompson, 216 Court House Bldg., St. Paul 2, Minn.

Sep. 29–Oct. 1—Missouri Section, at Sheraton-Jefferson Hotel, St. Louis. Secretary, W. A. Kramer, State Office Bldg., Jefferson City.

Oct. 13–16—Southwest Section, at Skirvin Hotel, Oklahoma City, Okla. Secretary, Leslie A. Jackson, Mgr.-Engr., Water Works, Robinson Memorial Auditorium, Little Rock, Ark.

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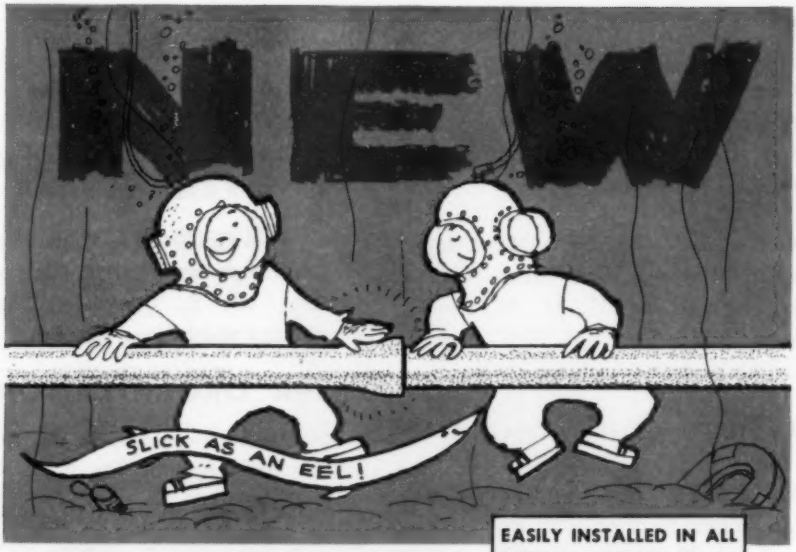

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Coming Meetings

(Continued from page 8)

Oct. 16–18—Iowa Section, at Fort Des Moines Hotel, Des Moines. Secretary, J. J. Hail, Supt., Water Dept., City Hall, Dubuque.

Oct. 20–23—Alabama-Mississippi Section, at Buena Vista Hotel, Biloxi, Miss. Secretary, C. M. Mathews, Public Service Com., 119 W. Commercial St., Yazoo City, Miss.

Oct. 23–24—West Virginia Section, at McClure Hotel, Wheeling. Secretary, H. W. Hetzer, Engr., West Virginia Water Service Co., Box 1906, Charleston 27.

Oct. 24–26—New Jersey Section, at Hotel Madison, Atlantic City. Secretary, A. F. Pleibel, Dist. Sales Manager, R. D. Wood Co., 683 Prospect St., Maplewood.

Oct. 29–Nov. 1—California Section, at Hotel St. Claire, San Jose. Secretary, Henry J. Ongerth, Sr. San. Engr., Bureau of San. Eng., 2151 Berkeley Way, Berkeley.

Oct. 30–Nov. 1—Chesapeake Section, at Sheraton-Park Hotel, Washington, D.C. Secretary, C. J. Lauter, 6955—33rd St., N.W., Washington, D.C.

Nov. 6–8—Virginia Section, at Hotel Roanoke, Roanoke. Secretary, J. P. Kavanagh, Dist. Mgr., Wallace & Tiernan Inc., 213 Carlton Terrace Bldg., Roanoke.

Nov. 10–13—Florida Section, at Roosevelt Hotel, Jacksonville. Secretary, J. D. Roth, P.O. Bin "O," Miami Beach 39.

Nov. 11–13—North Carolina Section, at Hotel Sir Walter, Raleigh. Secretary, W. E. Long Jr., State Stream Sanitation Com., Raleigh.

OTHER ORGANIZATIONS

Jun. 16–21—American Society for Testing Materials, Atlantic City, N.J.

Aug. 5–9—Gordon Research Conference on Ion Exchange, at Kimball Union Academy, Meriden, N.H. Write: W. G. Parks, Director, Dept. of Chemistry, Univ. of Rhode Island, Kingston, R.I.

Aug. 19–23—North Carolina Water Works Operators School, at Duke Univ., Durham, N.C.

Aug. 26–28—Hydraulics Div., American Society of Civil Engineers, at Kresge Auditorium, Massachusetts Inst. of Technology, Cambridge, Mass.

Oct. 6–9—Annual Conference & Products Exhibit, National Institute of Governmental Purchasing, at Netherland Hilton Hotel, Cincinnati, Ohio. Write: Albert H. Hall, Exec. Vice-Pres., 1001 Connecticut Ave., N.W., Washington 6, D.C.

Oct. 7–10—Federation of Sewage & Industrial Wastes Assns., at Statler Hotel, Boston, Mass.

Nov. 2–8—World Metallurgical Congress, sponsored by American Society for Metals, at Chicago, Ill.

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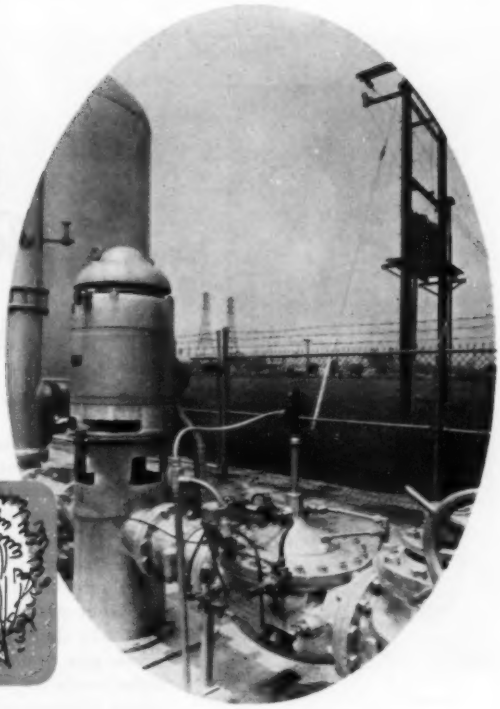

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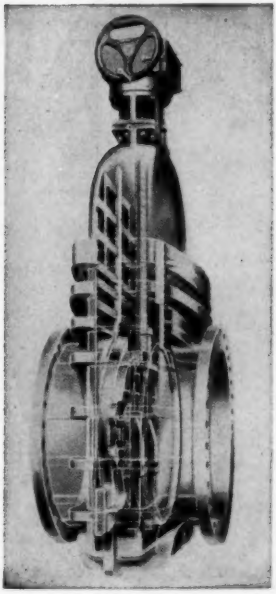

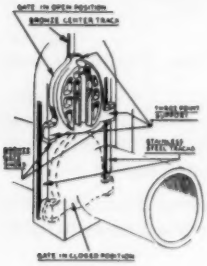

SQUARE BOTTOM VALVES

The Rensselaer Square Bottom Valve may well be called the "work horse" of the valve family. It is built to stand up under the severe conditions found in automatic operation, throttling, differential pressures and the constant opening and closing found in filtration plants and process industries.

A three-point gate support holds the downstream gate away from its seat ring at all points of travel except the final, fully closed position. Any tendency for the downstream gate to tilt and score the face of the seat ring under conditions of high water velocity or throttling service is eliminated.

At all points this valve is built for long life under constant and severe operation.

IN OPENING: the shoes slide up the stainless steel track inclines to the higher level of the tracks, lifting the gate clear of the bronze seat ring.

IN CLOSING: the gate does not come in contact with the bronze seat ring until the closing point is reached. Even when partly open, the gate is held away from the seat, eliminating all wear due to vibration.

Rensselaer Square Bottom Valves are made in sizes from 4 to 48" with any type end connection. By-passes, spur or bevel gearing, and cylinder or motor operation as desired. 20

LUDLOW & Rensselaer

LUDLOW RENSSELAER **VALVES & HYDRANTS**

Since 1861 THE LUDLOW VALVE MANUFACTURING CO. Troy, N. Y.

ANNOUNCING

ORANGEBURG®

SP Plastic Pipe

Produced from a superior new-type resin!
Completely slit-proof! Has greater strength!
Engineered to give lasting service!

Made only by Orangeburg

COMPARE THESE ADVANTAGES

- Resists acids, alkalies, salts
- Unaffected by detergents or soap solutions
- Light, flexible, easily handled
- Lengths to 400', fewer fittings
- Low installed cost, lasting service
- Slit-proof (no "pin-holing")
- Greater strength
- Higher heat resistance

APPROVED FOR DRINKING WATER SERVICE BY NATIONAL SANITATION FOUNDATION

Orangeburg *SP* is a new, stronger, flexible plastic pipe that gives superior performance. Takes higher pressures, higher temperatures.

Orangeburg *SP* is the only flexible plastic pipe made from a superior new-type polyethylene resin which took ten years of research to perfect. It is the extremely high molecular weight of this resin which gives Orangeburg *SP* exceptional strength and service life.

PROVED SUPERIORITY—Exhaustive tests prove Orangeburg *SP* Plastic Pipe is *completely slit-proof*—free from "pin-holing"! Exceeds every test known for polyethylene pipe!

IDEALLY SUITED FOR jet well, water service lines, underground sprinkler systems, irrigation, running water systems for farm buildings and livestock watering—and many other installations.

SPECIFY ORANGEBURG SP—made in ½" to 2" sizes, weighs only ⅛ as much as steel, installs faster and at less cost. Opens many new cost-saving applications. Send coupon now for full facts.

Backed by ORANGEBURG—a 64-year reputation for quality.
ORANGEBURG MANUFACTURING CO., INC., Orangeburg, N. Y. • Newark, Calif.

ORANGEBURG MANUFACTURING CO., INC., ORANGEBURG, N. Y., DEPT. JA-67
Please send descriptive literature on new Orangeburg *SP* Plastic Pipe.

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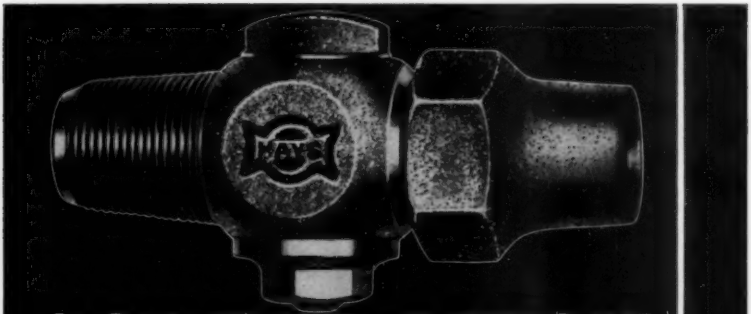
CITY_____ STATE_____



CORPORATION STOPS...

It Pays to Buy

HAYS®

High quality water service bronze, 85-5-5-5 mix . . .
Plugs individually ground in for perfect fit . . .
Corporation stops can be installed with any standard tapping machine . . .
Threads interchangeable with those of other manufacturers . . .
Conform to all A.W.W.A. standards.

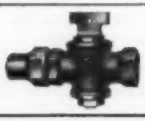
The same quality is maintained in the complete HAYS line of Water Service Products. Send for literature.

COPPER METER SETTERS

MODEL "B" TAPPING MACHINE

DUO-STOP CORPORATION STOP and SADDLE COMBINED

ROUNDWAY CURB STOP



Join the A. W. W. A. HAYS is one of the eleven Charter Members of the Manufacturers Section of the American Water Works Association.

HAYS®

WATER WORKS PRODUCTS

HAYS MANUFACTURING CO.
ERIE, PA.

HOMEWOOD ANTICIPATES WATER REQUIREMENTS TO 1980

To solve a water storage problem caused by a three-year population growth from 5,887 to 10,600 people, and to handle water storage for a population of 21,500 anticipated by 1980, the Village of Homewood, Ill., selected this 500,000 gallon water tank designed, fabricated and erected by Graver. Graver's 100 years of experience and nationwide organization can render valuable assistance in solving your water storage problem, too!

GRAVER TANK & MFG. CO., INC.

New York • Philadelphia • Edge Moor, Del. • EAST CHICAGO, INDIANA
Pittsburgh • Detroit • Chicago • Tulsa • Sand Springs, Okla.
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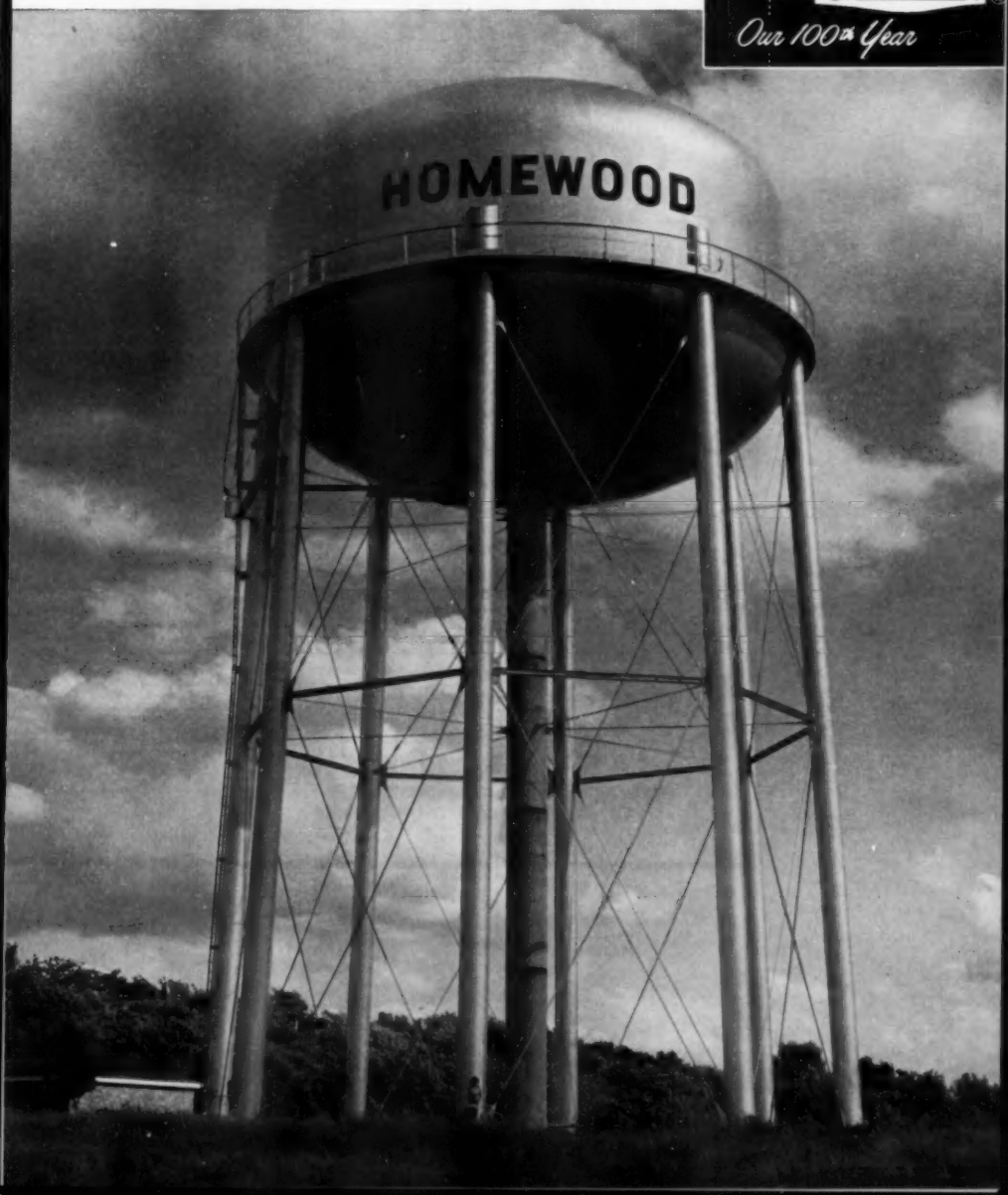
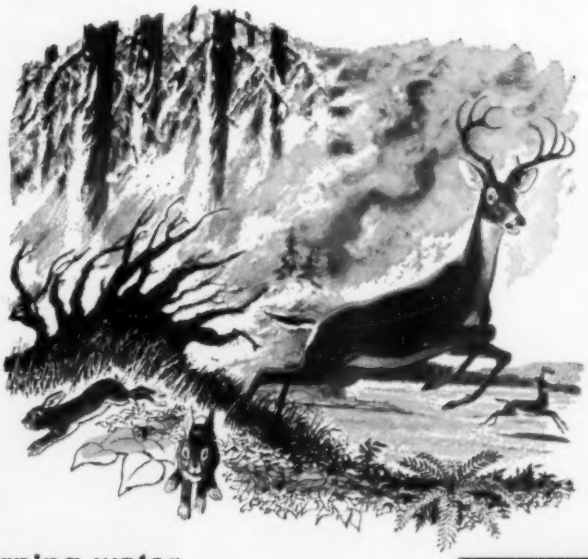
Our 100th Year





burning water...

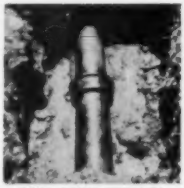
A carelessly flicked match or cigarette...

A forest dies. Water, no longer absorbed by the sunbaked soil, runs off... carries with it irreplaceable topsoil. Another natural watershed... life and health for thousands... is lost. Sometimes, for centuries!

You can help stop this criminal waste of God-given resources. In the woods, be careful of matches and campfires. As for water:

1. Encourage future planning of water facilities.
2. Support realistic water rates and water supply bond issues.
3. Conserve water wherever you can.

"Plentiful as water" no longer applies to America.



STILL GOING STRONG!

This 8" cast iron water main laid in Williamsport, Pennsylvania in 1855. Carrying water from the city's reservoir to its distribution system, it has been in continuous use for 102 years and is still in excellent condition.

Performance like this is another of the many reasons forward-looking water officials specify cast iron pipe. It's America's Number One Tax Saver... and the record proves it!

CAST IRON PIPE
RESEARCH ASSOCIATION SUITE 2440, PRUDENTIAL PLAZA, CHICAGO 1, ILL.

MODERNIZED **cast iron**

WATER...

IS EVERYONE'S BUSINESS!

The sooner Americans realize the gravity of our water problem the better it will be for them . . . and for you.

No easy job convincing *your* community it can no longer take water for granted. But advertisements* like the one opposite help you.

Not only do they warn of the growing seriousness of our water problem; they tell Americans what to do about it.

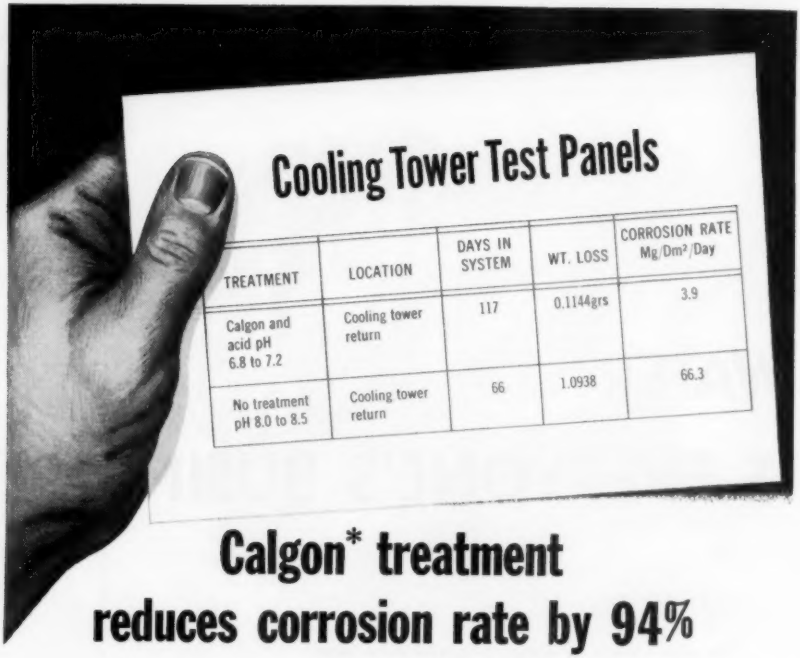
This means more support, sympathy and cooperation for *your* program . . . big or small as it may be.

CAST IRON

Cast Iron Pipe Research Association, Thos. F. Wolfe, Managing Director, Suite 3440, Prudential Plaza, Chicago 1, Ill.

**Appearing in:* Nation's Business, Newsweek, Saturday Evening Post, U. S. News & World Report.

pipe FOR MODERN WATER WORKS



Calgon* treatment reduces corrosion rate by 94%

... *system cleaned*

The chart shows the effect of Calgon treatment in this 20,000 gallon per minute recirculating cooling system. The corrosion rate as indicated by steel test strips was reduced from 66.3 Mg/Dm²/day to 3.9 Mg/Dm²/day. This reduction of 94% was obtained despite the fact that the test unit consisted of coupled steel and copper plates, creating a galvanic cell which would normally increase the corrosion rate severely. The copper strips showed no corrosion.

The low pH-Calgon treatment did more than achieve an extremely low corrosion rate. It also removed old corrosion products from the system, stepping up system efficiency, and making the treatment itself more effective.

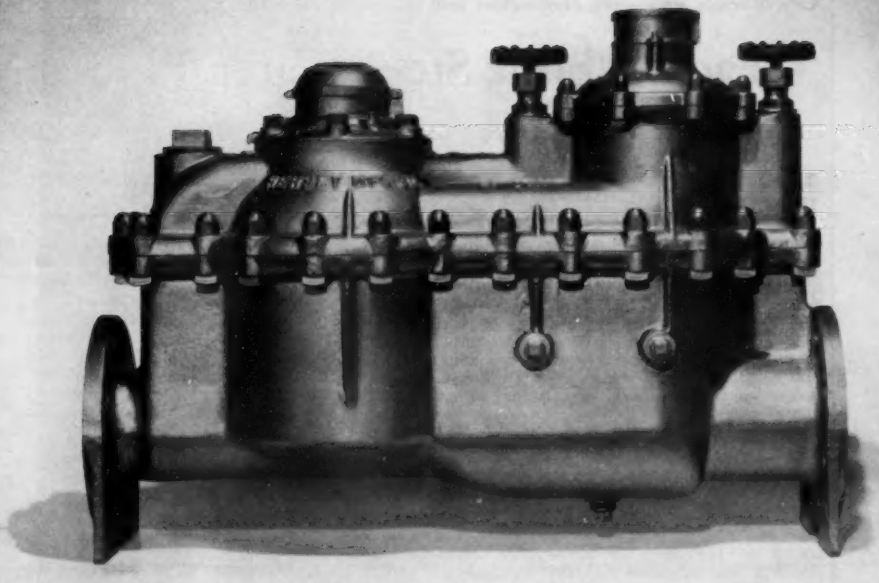
These results definitely indicate that for the less complicated corrosion problems no supplemental inhibitor of any kind is required in conjunction with the use of Calgon brand sodium hexametaphosphate. However, the Calgon Company has developed specific answers to water damage problems of all kinds. If necessary, iron and steel surfaces can be given fast and more complete protection with Calgon composition TG, remarkable for its accelerated film forming ability. Copper or copper alloy corrosion can be prevented with Coraid, which is effective at both high and low pH values. Protection is provided for the entire system, from cooling towers on through.

Write or phone for information on how Calgon Engineering Service can help you.

*Calgon is registered trademark.

CALGON COMPANY

A DIVISION OF HAGAN CHEMICALS & CONTROLS, INC.
HAGAN BUILDING, PITTSBURGH 30, PENNSYLVANIA
DIVISIONS: CALGON COMPANY • HALL LABORATORIES



Unquestionably

HERSEY

COMPOUND METERS

are unequaled for the registration of all rates of flow. All Bronze Case, 2" to 6" inclusive.

HERSEY MANUFACTURING COMPANY

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BRANCH OFFICES: NEW YORK — PORTLAND, ORE. — PHILADELPHIA — ATLANTA — DALLAS — CHICAGO
SAN FRANCISCO — LOS ANGELES

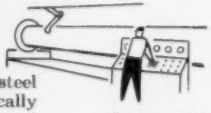
City officials, engineers, contractors will be interested in these . . .

Facts About Steel Water Pipe

COMPARE THE COSTS

This scale drawing compares a single 40-ft length of steel pipe with two 16-ft lengths of rigid-walled pipe of the same inside diameter. The steel pipe has thinner walls and a smaller outside diameter; weighs only about one-fifth as much per ft of length. Results: the steel pipe costs less to ship and handle; requires a smaller ditch, fewer bell holes, fewer joints—only 132 per mile.

TESTED FOR STRENGTH



Every length of steel pipe is hydrostatically tested at the shop in accordance with AWWA specifications—usually to double the working pressure. Steel pipe can withstand from 3 to 4 times the working pressure before bursting! It safely resists water-hammer, shock loadings and surge.

BEAM STRENGTH

Steel pipe has the structural strength that is characteristic of tubular steel. It can span long washouts; is often handled in multiple lengths during installation. And steel pipe can stand up under the weight of extremely heavy cover.

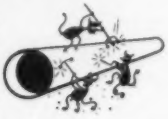
ELASTICITY

Steel "gives" under loads that would cause more rigid materials to crack or break. Steel pipe can "absorb" traffic vibration as well as shock due to explosions and earth tremors. Its elasticity allows it to transmit much of the load to the surrounding earth. This is not true of rigid-walled pipe.

LEAKPROOF JOINTS

100 pct bottle-tight joints are a practical reality with steel pipe, whether Dresser couplings or welds are used. That means no water wastage, no costly washouts. And you needn't fear contamination of the contents due to infiltration from without. These joints are quickly made, they're permanent, and they're strong.

CORROSION-RESISTANCE



Modern methods of lining steel pipe with hot-spun coal-tar enamel make it immune to corrosion and incrustation. There is no known time limit to this protection. Many tar-enameled lines have been in service for upwards of fifty years. Coal-tar enamel provides the smoothest surface obtainable, assuring high flow coefficients year after year. Coatings and wrappings protect the pipe from moisture, acids and alkalis.

WIDELY USED

Large-diameter steel pipe is the growing choice of planners of municipal and industrial water systems. Some recent users of Bethlehem Steel Pipe are: New York City, New Orleans, Philadelphia, Savannah, Reading, Cincinnati, Atlanta, Omaha, Worcester, Colorado Springs and Boston. Further proof of the superior qualities of steel pipe is its use in thousands of miles of large-diameter gas and oil lines, as well as in high-pressure penstocks throughout the world.

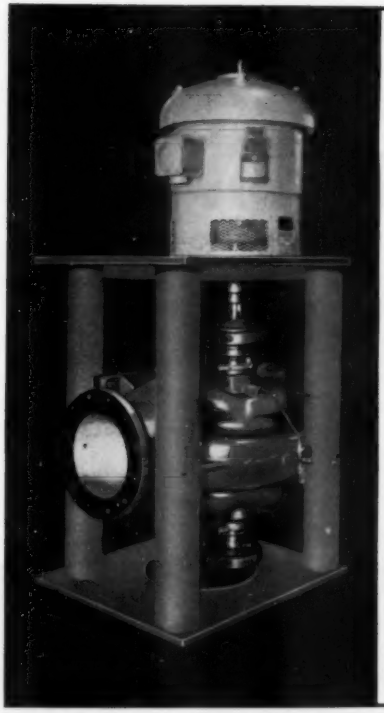
If you would like to have further information about steel water pipe, kindly contact the nearest Bethlehem sales office.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL



Save 50% Floor Space by installing Wheeler-Economy Horizontal Pumps Vertically!

Typical vertical installation of Wheeler-Economy Single Stage, Double Suction Pump. These High-Head Pumps, usually installed horizontally, can easily be mounted vertically, with a 50% saving in floor space. Motor here is located directly over Pump, but it could have been mounted on a floor some distance above Pump.

How to save floor space is a perennial problem at municipal water works. One large midwestern municipality solved this problem recently when booster pumps were installed—with an assist from C. H. Wheeler:

Double Suction Wheeler-Economy Pumps were installed vertically instead of horizontally, thus saving half the floor space! Another advantage of this type installation is that vertical pump mounting simplifies corner installation of pumps, because in many instances the discharge elbow can be located at 90° from the inlet.

The only change in pump construction necessary to change this Wheeler-Economy horizontal installation to a vertical one, was a quick, easy modification in the placement of the thrust bearing on the pump.

If you have a pump installation involving limited space or special features, contact your Wheeler-Economy representative, or write direct to C. H. Wheeler.

C. H. Wheeler Mfg. Co.
Economy Pump Division
19th and Lehigh Avenue, Philadelphia 32, Pa.

☐ Please have a Wheeler-Economy representative contact me.
☐ Send me catalog A-155.
☐ Please send information on_____

NAME
TITLE
CITY, ZONE
STATE

Economy Pump Division
C·H·Wheeler Mfg·Co·
19TH & LEHIGH AVENUE
Philadelphia 32, Pennsylvania

Centrifugal, Axial and Mixed Flow Pumps • Steam Condensers • Vacuum Equipment • Marine Auxiliary Machinery • Nuclear Products

Mean Job? Tough Requirements?

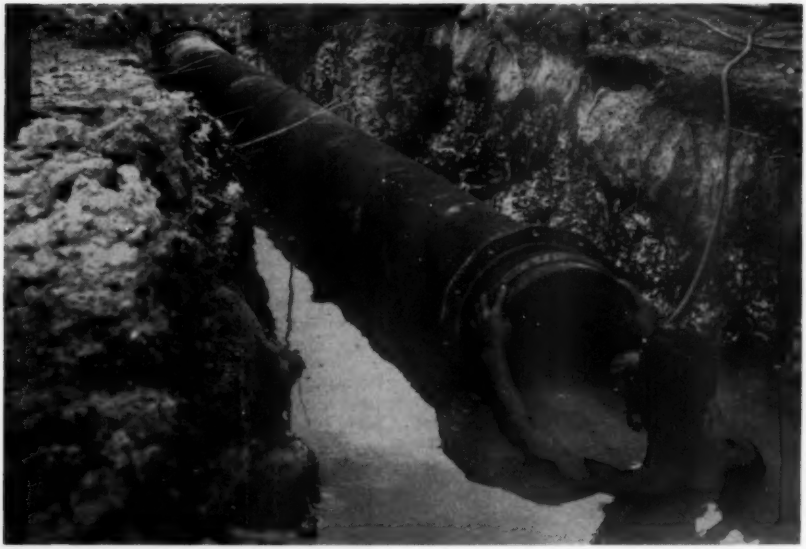
AMERICAN

CAST IRON PIPE

Happily, not all pipe must be installed under conditions as difficult as this Florida job. But when conditions — both for installation *and* service — are severe, American Cast Iron pipe is your wisest choice.

Supplied with the easy-to-assemble joint that best fits your requirements, American Cast Iron pipe goes down fast — to stay. The outstanding service of cast iron pipe for a century or more, under a wide variety of conditions, is a matter of record.

If installation or service conditions are getting you into deep water, call in your American Cast Iron Pipe Company representative. He can help you out.



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Kansas City, Minneapolis, Dallas, Denver, Pittsburgh, Orlando, New York, Cleveland, Los Angeles, San Francisco, Chicago, Birmingham

AMERICAN CAST IRON PIPE CO.
BIRMINGHAM 2, ALABAMA

FOR THE BEST IN *Water Meters*

go

ALL AMERICAN

AMERICAN METERS

Build Water Revenue

Here are some of the design features of American Meters that help you build Water Revenue:

A. A thick reinforced measuring disc is used to reduce slippage between the disc and measuring chamber wall. With this construction the clearance can be sufficient to prevent damage from grit or scale and still make a more efficient seal than is possible with a thin disc at the same clearance.

B. The seal between disc and measuring chamber is maintained in any position.

C. Absence of a thrust roller reduces friction and avoids noise.

D. Precision machining of all parts reduces friction and wear for continued measuring accuracy.

If you want full revenue from the water you supply, "go all AMERICAN."

BUFFALO METER CO. 2914 MAIN STREET BUFFALO 14, N. Y.

HOW TO SELECT WATER-CONDITIONING EQUIPMENT

(NO. 3 OF A SERIES)

Precipitation Equipment

Basically, precipitation equipment converts water impurities to the form of large, dense, suspended particles; then it separates these particles from the water.

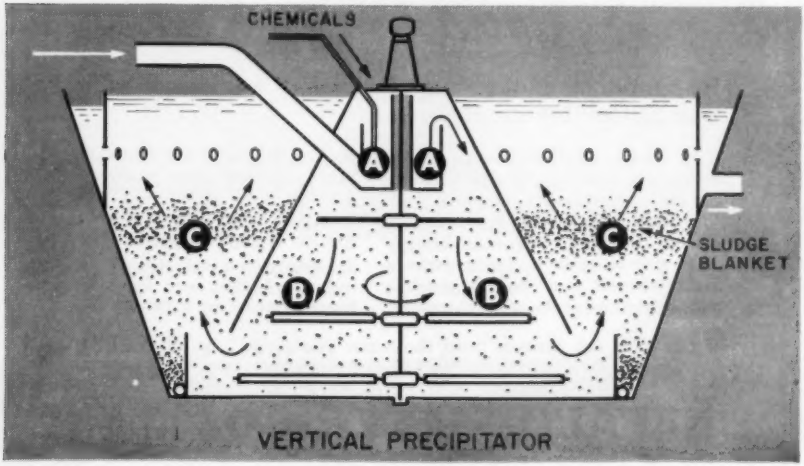
The first step is accomplished with chemicals. Hardness, for example, is precipitated by adding lime (and soda ash, if required). The precipitated hardness and other suspended impurities such as turbidity or oxidized iron and manganese are made to coalesce into larger particles by adding alum or iron salts. These salts also form their own dense, floc-like precipitate which absorbs the suspended material to form even larger particles.

The insoluble particles must then be separated from the water. Early methods used settling basins where precipitates settled slowly as the water flowed through, requiring 2 to 4 hours or longer detention time. Modern equipment keeps precipitates in suspension to serve as nuclei on which fresh precipitates form. This results in larger, denser particles that absorb more of the fine particles and are more easily separated from the water.

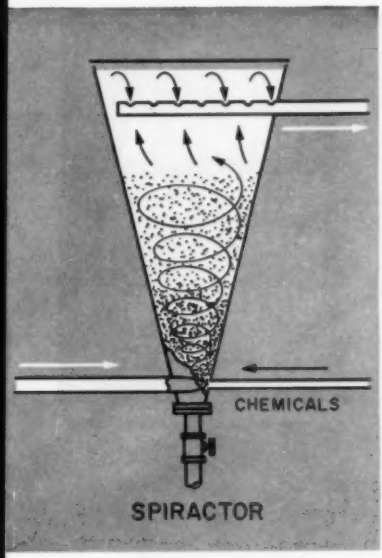
PRECIPITATOR for removing hardness, turbidity, color, iron, manganese.

Chemicals are mixed with influent at A. As water flows downward through zone B, precipitates form, "seeded" by recirculated sludge. At C, floc has formed a sludge-blanket filter suspended by upward motion of the water. Excess sludge is concentrated and periodically drawn off.

Because of short detention time, capacity is about 4 times that of conventional coagulation and settling basins of the same size. Basic designs include vertical types as illustrated, vertical types for installation in existing tanks, horizontal types built into new or existing concrete basins and smaller "package" types for bottling plants, etc.



VERTICAL PRECIPITATOR



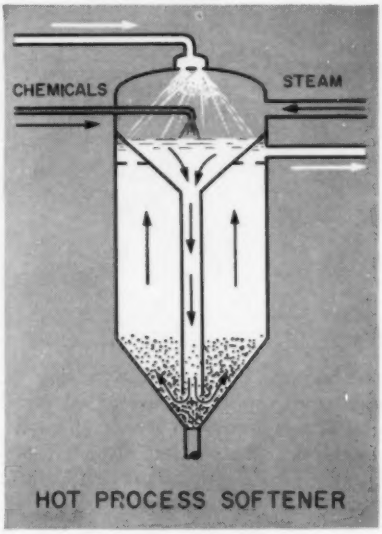
SPIRACTOR® for softening clear hard water.

The water, lime (and soda ash if required) enter at bottom of cone. The treated water rises with a swirling motion and suspends a bed of fine granules of calcium carbonate or other catalyst which speed softening reactions. The precipitated hardness deposits on the granules which become heavy and work down to the bottom of the cone where they are drawn off then easily dried and dumped. The softened water rises above the bed of granules to the outlet.

Provides very high flow rates in relation to its small floor space. Detention period: 8 to 10 mins. Recommended for municipal or cooling water.

HOT PROCESS SOFTENER for removing hardness and silica from boiler feedwater.

The water is first heated to within a few degrees of boiling by spraying through steam. Then it is mixed with softening chemicals which react very rapidly and efficiently at this temperature. It then flows down to the bottom and upward through a suspended sludge blanket of precipitated solids which effectively reduces silica and filters out the bulk of the turbidity. Combination softeners with built-in condensate heater and storage compartment and/or steam scrubber (deaerator) are also available.



The effluent is filtered to remove last traces of suspended matter. Where zero hardness is required, Hot Process Softeners may be followed by a zeolite softener.

• • • •

LET US HELP WITH YOUR PROBLEMS

For detailed information on these or any other types of water conditioning equipment, write: The Permutit Company, Dept. JA-6, 330 West 42nd St., New York 36, N. Y. or Permutit Company of Canada, Ltd., Toronto 1, Ont.

PERMUTIT®

rhymes with "compute it"

Water Conditioning
Ion Exchange • Industrial Waste Treatment

TECHNICAL REPORT NO 1
and smooth surfaced dumb-bell type waterstops
TESTS and METHODS of TESTING DURAJOINT, & DURASEAL, Waterstops
STS and TEST RESULTS ON JOINT, & DURASEAL, Waterstops
NEW
TECHNICAL MANUALS ON WATERSTOPS AVAILABLE

We have prepared, in conjunction with various testing companies, a series of factual, technical reports on the subject of waterstops. These Technical Reports cover the many aspects of adequate concrete joint design and should prove to be a valuable addition to your design files. Although these reports are strictly technical information and not sales catalogs, they conclusively prove that DURAJOINT and DURASEAL PVC Waterstops are the only waterstops on the market that will produce a practically 100% watertight joint. Check the coupon below for your free copies of these Technical Reports. Why not mail it now while you are still thinking about it?

DURAJOINT TECH-TIPS

. . . a series of Technical Data Sheets that contain complete information on the design, handling, splicing, installation and structural recommendations on the application of DURAJOINT and DURASEAL Waterstops. Send coupon today for your free set of DURAJOINT "Tech-Tips."

NATIONAL DISTRIBUTION

"DURAJOINT" enjoys national distribution through the distributors of Tecon Inc. in the 11 western states and W. R. Meadows, Inc. in the 37 states of the mid-western, southern and eastern portions of the United States.

DURAJOINT TECHNICAL INFORMATION *Center*

121 HILL AVENUE • AURORA, ILLINOIS

Please send me, without obligation, the following:

DEPT. 34

- ☐ **TECHNICAL REPORT NO. 1**... How Cross Section Design Affects Bonding to the Concrete.
- ☐ **TECHNICAL REPORT NO. 2**...Tests and Methods of Testing Polyvinylchloride Waterstops.
- ☐ **TECHNICAL REPORT NO. 3**...DURAJOINT Tests and Test Results by the U. S. Testing Company, Inc.
- ☐ **TECHNICAL REPORT NO. 4**... Hydrostatic Pressure Tests on DURAJOINT and other Waterstops.
- ☐ **DURAJOINT** "Tech-Tip" Series.
- ☐ Have representative call.

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FIRM_____

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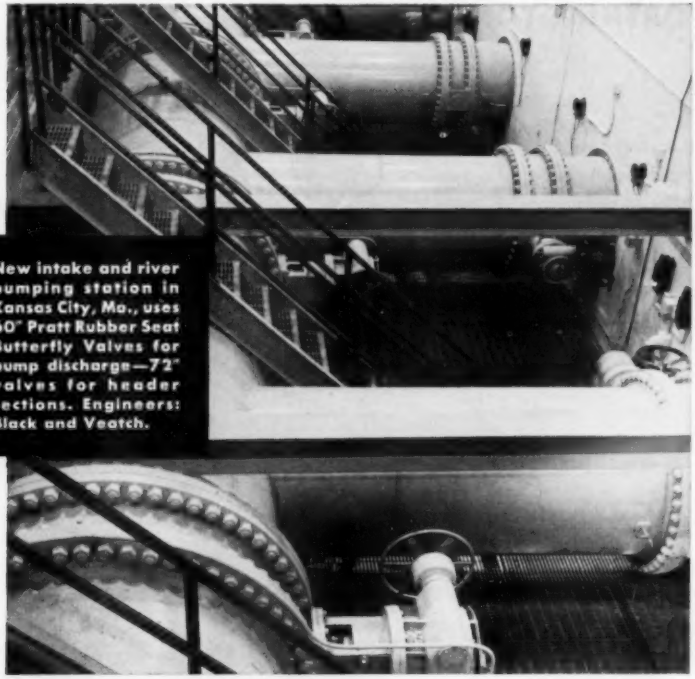

New intake and river pumping station in Kansas City, Mo., uses 60" Pratt Rubber Seat Butterfly Valves for pump discharge—72" valves for header sections. Engineers: Black and Veatch.

KANSAS CITY:
Rugged efficiency in a minimum space

Look! A modern pumping station with compact, unobtrusive large-diameter valves that require no more clearance than a standard pipe flange, and operators that are equally compact. Face-to-face dimensions of these 60" and 72" diameter Henry Pratt Rubber Seat Butterfly Valves are only 15" and 18" respectively.

Specifying Pratt valves means important savings in space and installation costs—but even more important, economy through years of efficient, maintenance-free operation.

Pratt originated the Rubber Seat Butterfly Valve and has installed more of them than any other manufacturer.

For valve design with a 50 year reputation for practical imagination, see Henry Pratt.

NEW! Latest, most accurate pressure drop and flow data, conversion tables, discussion of butterfly valve theory and application plus other technical information.
Write for Manual B-2C.

HENRY PRATT

RUBBER SEAT Butterfly Valves

Henry Pratt Company, 2222 S. Halsted St., Chicago 8, Ill. Representatives in principal cities

WORTHINGTON-GAMON

WATCH DOG

The meter used by thousands of municipalities in the U. S.

WATER METERS

"Watch Dog" models . . . made in standard capacities from 20 g.p.m. up: frost-proof and split case in household sizes. Disc, turbine, or compound type.

SURE TO MEET YOUR SPECIFICATIONS FOR ACCURACY, LOW MAINTENANCE, LONG LIFE.

Before you invest in water meters, get acquainted with the design and performance advantages which make Worthington-Gamon Watch Dog Water Meters first choice of so many municipalities and private water companies in the United States.

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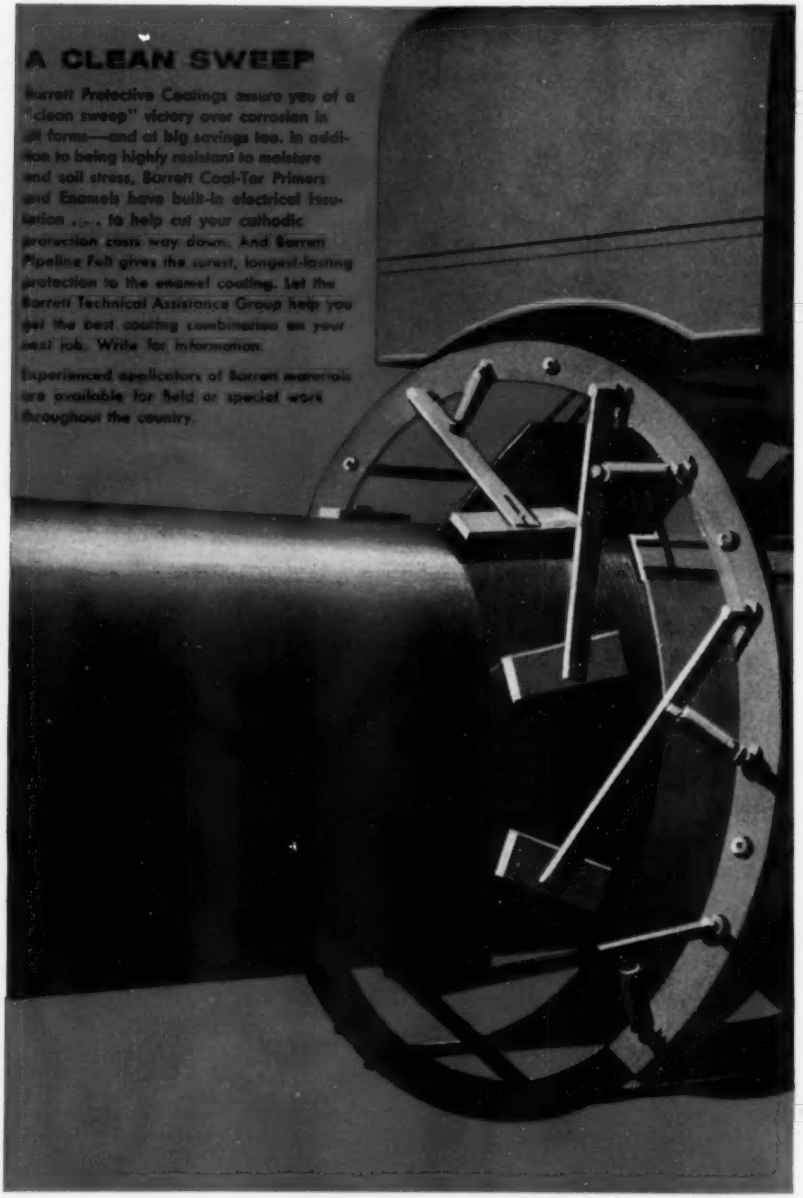
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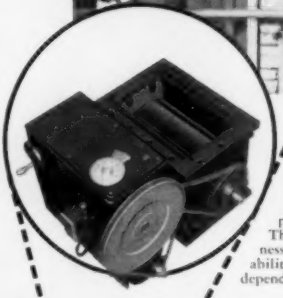

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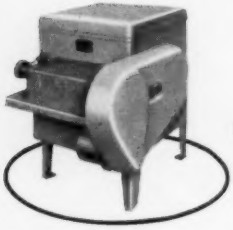

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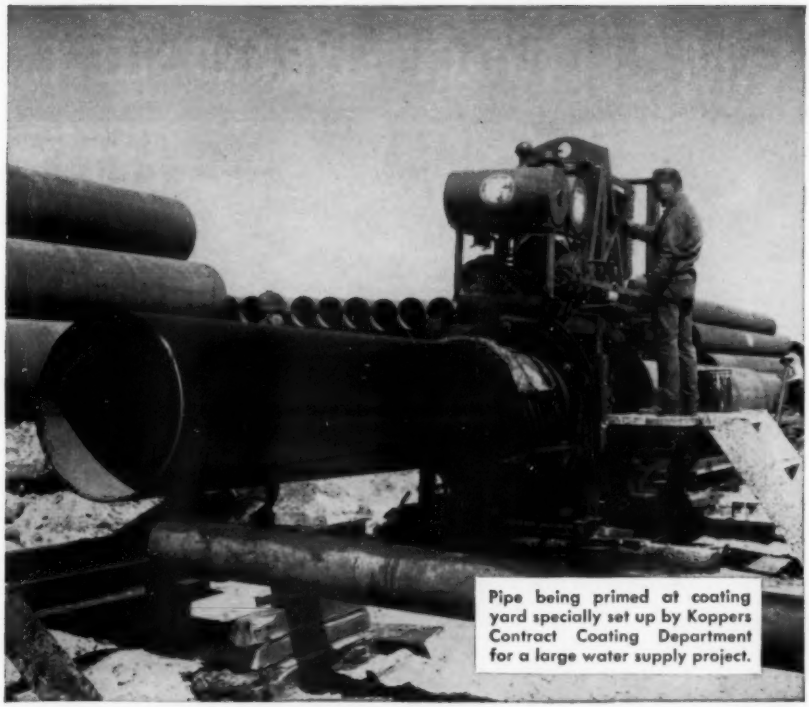

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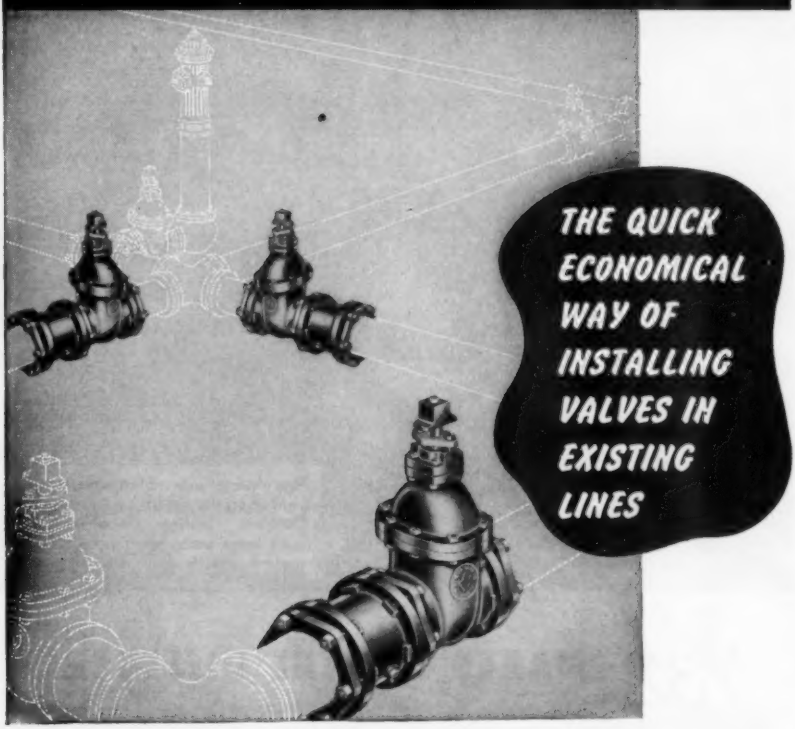

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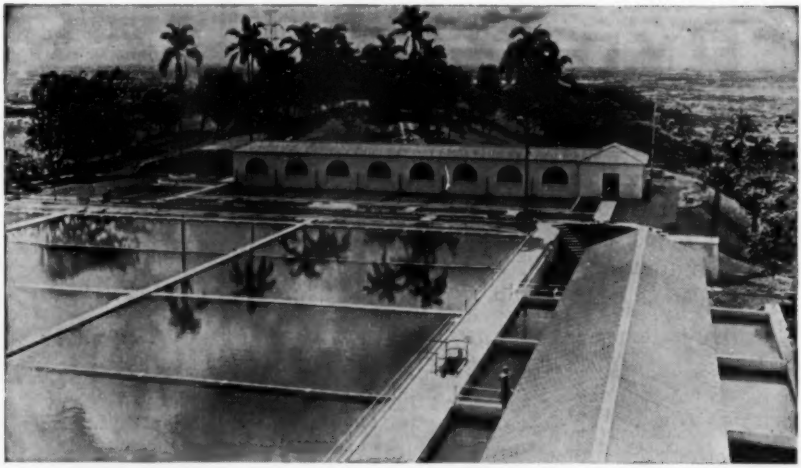

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Journal
AMERICAN WATER WORKS ASSOCIATION
VOL. 49 • JUNE 1957 • NO. 6

Impact of Water Use for Air Conditioning on Chicago's Water System

Hyman H. Gerstein

A paper presented on Mar. 20, 1957, at the Illinois Section Meeting, Chicago, Ill., by Hyman H. Gerstein, Asst. Chief Water Engr., Dept. of Water & Sewers, Chicago, Ill.

THE Chicago water supply system is now confronted with economic and operating problems of a most serious nature because of the wasteful use of water brought about by the amazingly rapid increase in installations of non-conserved water-using air-conditioning equipment for industrial, commercial, and domestic purposes. Because of the present low water rates and the short air-conditioning season, the revenue derived from the sale of water for this purpose cannot begin to cover the annual fixed charges for construction of the large standby plant capacity needed to supply the high water demands of air-conditioning water usage.

In general, air-conditioning installations may be divided into three categories:

1. *Air-cooled units which use no water.* The widely used window units are of this type. Capacities are usually ½ to 5 tons. This type presents no problem to water supply system.

2. *Water-cooled units equipped for conservation.* These units use cooling towers or evaporative condensers which recirculate the cooling water and require makeup water at a rate of no greater than 0.15 gpm per ton of air conditioning. Such water use usually does not place undue strain on an existing water system.

3. *Water-cooled units of the non-conserved type.* Cooling water is passed through these units at a maximum rate of 1.5 to 2 gpm per ton of air conditioning and is then discarded, after one passage through the equipment. It is this uneconomical high-rate water use which causes serious water supply difficulties in the Chicago water system.

Growth of Air Conditioning

The best estimates available indicate that at the beginning of 1957, a total of 296,000 tons of water-using air conditioning was installed in Chicago. Of this total, 81,000 tons, or 25 per cent,

is installed in the downtown area. It is estimated that no more than 10–15 per cent of all installations is equipped for water conservation. These estimates are based on information obtained from permits for new installations issued by the Department for the conditioning installations for the entire city and the downtown area from 1932 to 1956.

It is probable that the estimates include air-conditioning equipment that has become obsolete and abandoned, but there is no way of correcting for

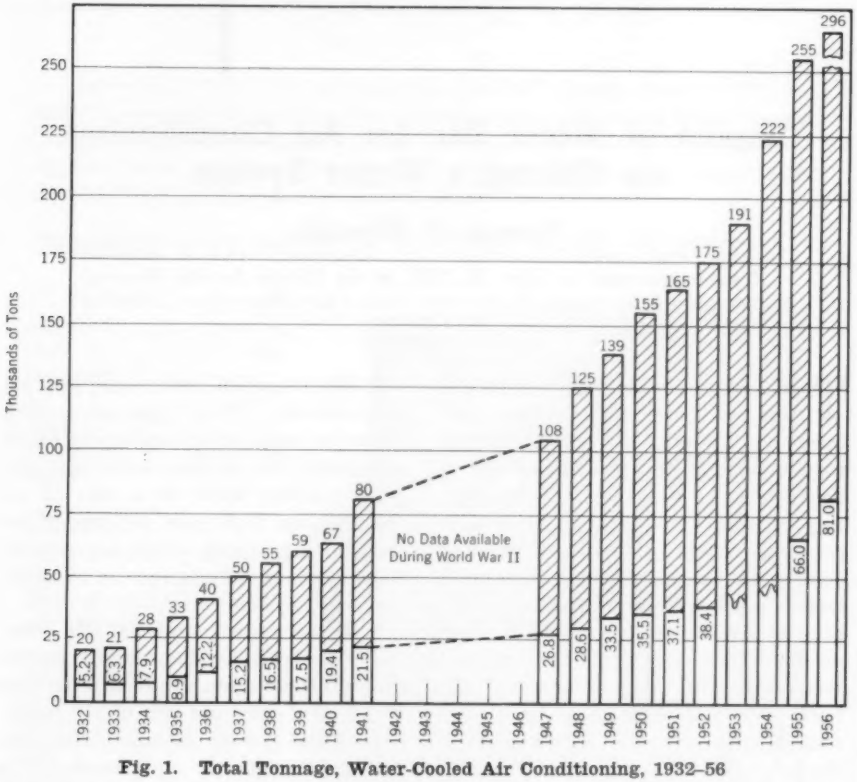

Fig. 1. Total Tonnage, Water-Cooled Air Conditioning, 1932–56

Totals are estimated from data from prior research and current permit records of the city of Chicago. Unshaded portions represent tonnage for the "loop" or downtown Chicago area only.

Inspection of Steam Boilers, Unfired Pressure Vessels, and Cooling Plants, and from data obtained from earlier surveys made by the Commonwealth Edison Company. Figure 1 shows the year-by-year growth in water-using air

this factor. Since there is evidence, however, that a substantial tonnage of air conditioning has been installed without permits and is not included in the totals, it is believed that the estimates of total tonnage installed are conserva-

tive. Studies indicate that most of the air conditioning installed without permit consists of the smaller-size (under 5-ton capacity), water-using, central units for homes, which have been installed in considerable and increasing number during the last few years.

By applying the published predictions (*1*) of the air-conditioning industry on the general trends in sales, it can be conservatively estimated that by 1960, over 560,000 tons of water-cooled air conditioning will be in use in Chicago (Table 1).

It is reasonable to believe that competition will compel air conditioning of a large percentage of the rentable facilities in the downtown area in the next 5 to 10 years. Air conditioning of all downtown facilities would require 200,000 tons of capacity.

Water is used in air-conditioning equipment to remove the heat from the refrigerant by cooling the condenser coils. Proper cooling of the refrigerant with a water temperature of 70°F normally requires a water flow of 1.5 gpm for each ton of air-conditioning capacity. At a water temperature of 78°F, the requirement is approximately 2 gpm per ton of capacity. Since the water temperature of the Chicago water supply rarely exceeds 70°F, the basic water requirement for nonconserved air-conditioning equipment is generally estimated at 1.5 gpm per ton capacity. This high rate of water use is wasteful because it is possible, by use of auxiliary equipment such as cooling towers or evaporative condensers, to recirculate the cooling water and thereby reduce requirements 90–95 per cent.

Water Used by Air Conditioners

Some conception of the amount of water needed by wasteful, nonconserved air conditioning is given by the fact that a 1,000-ton unit uses water at the rate of 2.16 mgd. (Such water plant capacity is sufficient to supply amply the average needs of a community of 20,000 population.) By the use of an efficient cooling tower, the water requirement from the city mains would be reduced to considerably less than 200,000 gpd.

In the Chicago region, air-conditioning equipment is generally operated approximately 1,000 hr per year, mostly during the 3-month period between Jun. 15 and Sep. 15. The water demand for this use is of seasonal nature and occurs simultaneously and in addition to the summer peaks of ordinary domestic and industrial use for irrigation and refrigeration.

TABLE 1

*Water-using Air Conditioning in Chicago**

Year	Total	Downtown Area
1935	33	8.9
1940	67	19.4
1945†	—	—
1950	155	35.5
1955	255	66.0
1956	296	81.0
1960‡	560	150.0

* In thousands of tons.
† No data available.
‡ Estimated.

Figure 2, prepared from 1954 pumpage data, shows a pumpage load curve on a dry hot day, and the estimated hourly distribution of water for various uses. It indicates that an approximately 250-mgd rate of water use for air conditioning occurred during the hours 3–6 PM. This was in addition to the other water loads on the system, and represented a rate of water usage of 0.78 gpm per ton of estimated total installation of air conditioning. The above use of water for air conditioning

is sufficient to supply the maximum rate requirements of the city of Milwaukee, which supplies a population of approximately 700,000.

for the entire water system was at the rate of 0.78 gpm per ton of air conditioning—approximately half the accepted rate for nonconserved water us-

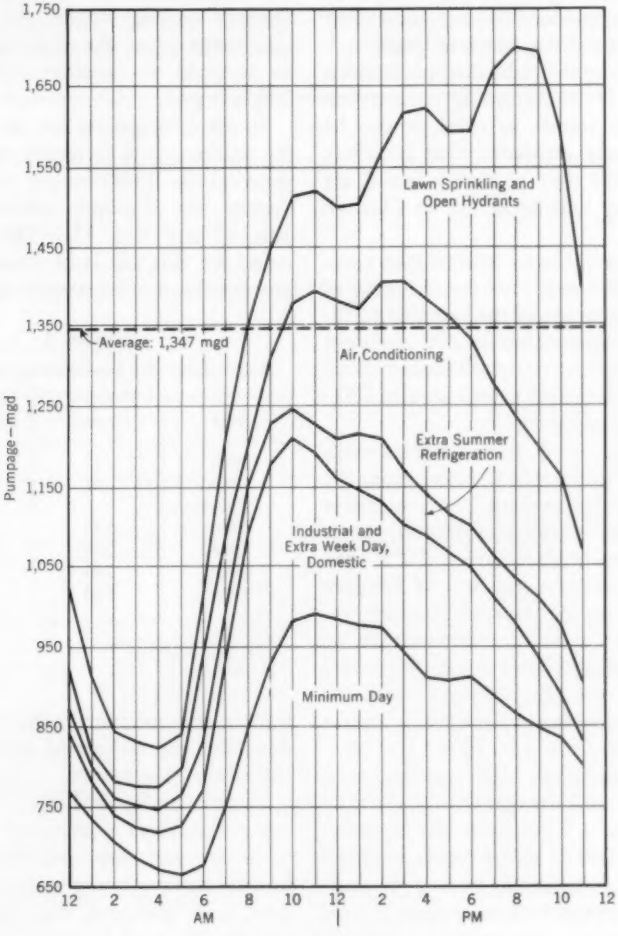

Fig. 2. Typical Pumpage Curves

Data from Chicago Bureau of Water, 1954, showing influence of various designated loads.

It is interesting to observe that the estimated water usage attributed to air conditioning on the peak day of 1954

age for an individual air-conditioning unit when the water temperature is 70°F. It is probable that the low wa-

ter usage rate figure which was obtained from collective use of air-conditioning equipment reflects the effect of operation of installed conservation equipment and nonoperation of some of the units at the time the observations were made.

Estimates of the probable water demands caused by new air-conditioning installations (assuming continuation of nonconserved use) indicate a range in demand of 0.7 gpm per ton to 1.5 gpm per ton if all new installations are of the nonconserved type and if all are operated at the same time.

Water used for cooling industrial and commercial refrigeration is not considered as serious a problem for the water system as air conditioning, because it is year-round use and because high operating costs involved—even at low water rates—make the use of conserving equipment obligatory from an economic standpoint.

The best estimate of the amount of water-using air-conditioning equipment in the downtown area of Chicago, a highly concentrated area covering 0.94 sq miles, is 81,000 tons, of which approximately 15,000 tons is equipped for water conservation. A study of the floor area in the various buildings for which air conditioning will probably be provided in the next 5 to 10 years, indicates an ultimate total water-using air-conditioning capacity of 200,000 tons for the downtown area.

A measure of the increasing use of water for air conditioning in that area is shown by comparisons of summer and winter water flow measurements. A measurement of the rate of water flow into the downtown area was made by water distribution engineers on the afternoon of Jul. 29, 1955, a hot dry day. The water consumption peak rate measured was 99.4 mgd. The normal maximum rate of water usage in this area, measured on the afternoon of Dec. 14, 1955, was 35.4 mgd. The difference, therefore, in water usage rates—64 mgd—is the water flow which may be largely attributed to air conditioning. This represents a rate of 0.68 gpm per ton of air conditioning based on the estimated installed capacity of 66,000 tons in 1955. The low water usage rate per ton of capacity obtained from collective use of air-conditioning equipment in the downtown area was probably due to the effect of the use of conservation equipment and of the nonoperation of some of the units at the time the observations were made.

If the ultimate air-conditioning capacity of 200,000 tons were installed without water conservation for the new installations, the water demand for this purpose would increase estimated demand to a range of 200 to 350 mgd. The increased plant capacity necessary to supply such demand would require rebuilding of water distribution facilities and sewers in the downtown area with the accompanying tearing up of the streets—all at tremendous cost. Fortunately, the seriousness of the situation has been recognized, and some of the large air-conditioning units now being planned are to be equipped for water conservation. It appears, however, that general installation of conserving equipment can be accomplished only by regulation.

Home Air Conditioners

Those considerations which apply to nonconserved use are also appropriate to home air conditioning. There has been a tremendous increase in installation of central air-conditioning units in both new and existing homes during the last few years. These units are usually from 1.5 to 5-ton capacity, and

their installation is expected to increase at an accelerated rate. It has been predicted that by 1958, 25 per cent of the new homes costing over $18,000 will have complete air conditioning. Since most of the single-family homes now buy water under assessed rates, it is important that information concerning all such installations be provided to the Bureau of Water. At present, most such units are installed without obtaining an air-conditioning permit, and no information is available for water collection assessment unless the installation is discovered by inspection of the premises. The city code also requires all premises having water-using air conditioning to be metered. The new assessed-rate schedule, effective May 1, 1957, is $12.70 per ton per annum for air conditioning. This just pays for the water use, but does not compensate for the large plant standby required for this short-season high-demand use.

It has been reported that efficient air-cooled central units have been developed in capacities up to 5 tons and that efficient air-cooled units up to 10-ton capacity may soon be available. An increase in such installations should result if restrictions on water use for small units become necessary in the future.

Past Policy

The impact of air-conditioning water demand on the operation of the Chicago water system was recognized at an early date by the city's engineering staff. Extensive studies were conducted and reports were prepared pointing out the dangers of nonconserved water usage as far back as 1935.

It is believed that the reason no definite regulatory action was taken, although the need for water conservation was recognized, is the fact that the existing Chicago water system plant has had, until recently, sufficient excess available capacity to supply all water demands, including the air-conditioning requirements—with the exception of a few peak days.

The increasing water demands of the growing population and industry in the city and the 55 suburbs supplied by the city system have now reached a point where the present system has had difficulty in meeting peak demands. The city has now embarked on a comprehensive program to provide the additional plant capacity needed to maintain adequate service for all consumers, based on reasonably conserved use of water. If nonconserved use of water for air conditioning is permitted to continue, it will require installation of much larger plant capacity than otherwise would be necessary.

It is interesting to note that the only time Chicago required conservation of air-conditioning water was in some downtown installations when *inadequacy of street sewers* to carry the water discharged from air conditioners was the controlling factor rather than inability of the water system to supply the demands.

Chicago Water System

The Chicago water system, which, at present, has an overall peak capacity of approximately 1,800 mgd, was constructed at a cost of $270,676,000, or approximately $150,000 per million gallons of capacity. The largest part of the plant was constructed under much lower price conditions than exist today, and, therefore, the unit cost was much lower than present day construction costs for new plant capacity. It has been conservatively estimated that the

reproduction cost of the Chicago water system is in the range of from $750,000,000 to one billion dollars. Taking the lower figure of this estimate, the present cost of replacement and additions is $417,000 per million gallons capacity. In subsequent calculations, the rounded construction cost figure of $400,000 per million gallons is used.

In 1956 the Chicago system pumped an average of 1,031 mgd, which is slightly less than the average that was pumped 20 years ago in 1936, when the annual daily average was 1,057 mgd. Although there has been practically no change in average pumpage during the last 20 years (because of an effective program of stopping wastage from underground leakage), an additional 200 mgd was made available without increasing the daily average amount of water pumped. The extra plant capacity thus made available has been enough to supply the water needs of a population increase of 700,000 in the Chicago service area, as well as the expanded industrial and fire protection needs.

Because of the addition of consumers and the increased use of water for lawn sprinkling, nonconserved air conditioning, and modern kitchen appliances, the maximum-day pumpage has increased from 1,365 mil gal in 1936 to 1,513 mil gal in 1955, and the maximum hour pumpage rate from 1,546 mgd in 1936 to 1,788 mgd in 1955. The all-time record peak hourly pumpage rate of 1,788 mgd occurred at 3 PM on Jul. 28, 1955, during an extremely hot and dry period. On that day, adequate service, with some exceptions, was provided for most consumers, although the pumpage rate at 3 PM nearly reached the maximum rate available with the existing plant capacity.

Conservation Equipment

It is possible, by the use of auxiliary equipment such as cooling towers and evaporative condensers, to conserve the water used after passage through air-conditioning units by recirculating it through cooling towers. The water requirement, with such equipment, is only that needed for makeup, to replace the water lost through evaporation. Efficient equipment of this type requires only 3 per cent makeup—a saving of 97 per cent on nonconserved equipment requirements. Generally, it is safe to expect a 90–95 per cent saving by use of water conservation equipment.

Estimated costs of installation of cooling towers or evaporative condensers range from $70 to $120 for each ton of air-conditioning capacity—the cost depending upon the size and type of unit—with a lower unit cost for the larger installations.

Because of the high first cost of installing conservation equipment, when the water rate is low, as it is in Chicago (16 cents per 1,000 gal after May 1), it is generally cheaper to discard water to the sewer after one passage through the air conditioner than to install and use conservation equipment. The water rate above which it begins to pay to install and use water conservation equipment is reported to be 16 cents per 1,000 gal. Obviously, the higher the water rate the larger the saving derived from conservation equipment.

It is possible and practicable for the large water demands for air conditioning to be radically reduced to a reasonable amount by use of water conservation equipment. Since owners generally will not install conservation equipment unless forced to do so by high water rates or by legislative ac-

tion, it is apparent that regulations requiring conservation must be promulgated without delay in order to avoid building expensive plant capacity necessitated by such wasteful use.

If it was assumed that all water-using air conditioning were to be equipped with relatively inefficient water conservation devices which required 10 per cent makeup, the recent peak rate of water usage of approximately 250 mgd attributed to air conditioning would be sufficient to supply 1,157,000 tons of air conditioning instead of the present 296,000 tons. Likewise, the 64 mgd used in 1955 for air conditioning in the downtown area would supply 300,900 tons of air conditioning instead of the present 91,000 tons.

Economic Aspects

A study of the economics involved in the use of wasteful nonconserved equipment shows that revenue from existing water rates can finance only a fraction of the annual fixed charges for constructing the new plant capacity required to meet the high-rate and short-season demands of nonconserved air conditioning. This is illustrated in the following computations:

1. Water plant capacity needed per ton, computed on the basis of 1.5 gpm of water flow required for each ton of nonconserved air conditioning, would be 2,160 gpd:

$$1.5 \times 1{,}440 = 2{,}160 \text{ gpd per ton}$$

2. Water plant cost per ton, using the previously mentioned conservative estimate of $400,000 per 1 mgd new plant capacity (or $400 per 1,000 gpd capacity) is $864:

$$\frac{2{,}160 \times \$400}{1{,}000} = \$864 \text{ per ton}$$

3. Annual fixed charges per ton, using a very low rate of 5 per cent for interest and depreciation, would be $43.20:

$$0.05 \times \$864 = \$43.20 \text{ per year per ton}$$

4. Annual revenue from nonconserved water used (per ton) for 1,000 hr of operation per year at the new water rate of 16 cents per 1,000 gal is estimated at $14.40:

$$\frac{1{,}000 \times 60 \times 1.5 \times \$0.16}{1{,}000} = \$14.40 \text{ per year per ton}$$

Therefore, for each ton of nonconserved air conditioning, the annual fixed charge cost to the city for the new plant capacity needed is $43.20, whereas the annual revenue from water used is only $14.40.

Under present regulations and water rates, the totally inadequate annual revenue derived from water accounts of this type cannot support the water supply costs for this wasteful usage unless all of the water customers of the system absorb the cost by paying higher rates than otherwise required.

Conclusion

The nonconserved use of water for air-conditioning equipment is an uneconomic and wasteful practice. The cost of new water plant capacity needed to service such use cannot begin to be supported by revenue derived from present water rates. Unless the wasteful use of water is regulated, or nonconserved water users are required to pay for the actual cost involved, it will be necessary to distribute the increased costs among all water consumers by substantial rate increases.

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1. *The Air-conditioning Boom Ahead.* Heating, Piping Air Conditioning, New York (1954).

High-Demand Restriction at Kansas City, Mo.

Melvin P. Hatcher

A paper presented on Feb. 7, 1957, at the Indiana Section Meeting, Indianapolis, Ind., by Melvin P. Hatcher, Director, Water Dept., Kansas City, Mo.

KANSAS City, in 1948, instituted a demand-distance type of rate for suburban water service. This is a two-part rate combining a charge based on the volume of water used, with demand charges based on maximum day and maximum hour during the summer months and with a factor in the demand charges for distance from the pumping station. The rate has been described in considerable detail in the JOURNAL (*1*).

The author believes the rate was the first of its kind. It has served well for it is quite workable and it brings about an equitable distribution of costs. Summer demands under the rate now account for a total of approximately 25 mgd out of a system total of approximately 150 mgd.

Figures 1 and 2 show an interesting by-product of the rate. Figure 1 shows a system demand excluding suburban service. The high evening peak due to lawn sprinkling is noticeable. Figure 2 shows the suburban hour-by-hour demand on the day at maximum system demand. The splendid conformance of the evening demands should be noted. The suburban demand rate includes an extra charge for hourly demands from 4:30 to 8:30 PM in excess of the average for the maximum day. Purchasers of water for suburban use find it worth their while to provide for their demands for these hours from storage. They hold down their demands during the hours of maximum demand on the system.

Air-Conditioning Service

Kansas City began its studies of the impact of air-conditioning demands in 1946. It is believed that the inspiration for these studies came in part from the report of studies made by the late Loran D. Gayton, Assistant City Engineer of Chicago. The author's first record of these studies dates back to 1937 (*2*).

Kansas City's first rate, aimed at the control of air-conditioning demands, became effective on Dec. 1, 1951. This rate included a special charge for summer consumption in excess of 150 per cent of winter consumption. The rate encountered vigorous objection from one brewery and several soft drink bottlers. As a result the whole water rate problem was studied again by a panel of engineers, including representatives from Burns and McDonnell Engineering Company, Black and Veatch, and Alvord, Burdick, and Howson. The report following that study recommended a special rate of 28 cents per 100 cu ft for water used for nonconserved air-conditioning service —the special rate being applied against 10,000 cu ft of water per summer season for each ton of air-conditioning capacity. Because of objections, the rate as finally adopted was 16 cents per 100 cu ft. For purposes of comparison this

is the equivalent of a demand charge of about $3.50 per ton per season. It was evident from the start that the 16 cents rate or the more recently adopted 18.2 cents rate would have little or no effect on whether air conditioning was operated on a conserved or nonconserved basis.

In May 1954 Black & Veatch, Consulting Engineers, completed a report showing the effect of air conditioning on future demands for water from the Kansas City system. They predicted an increase from 45,000 tons in 1954 to 366,000 tons in 1970. Without proper price controls for water used for air-conditioning service, this would account for a demand of 275 mgd for air-conditioning service in 1970. On the basis of this report, and with water

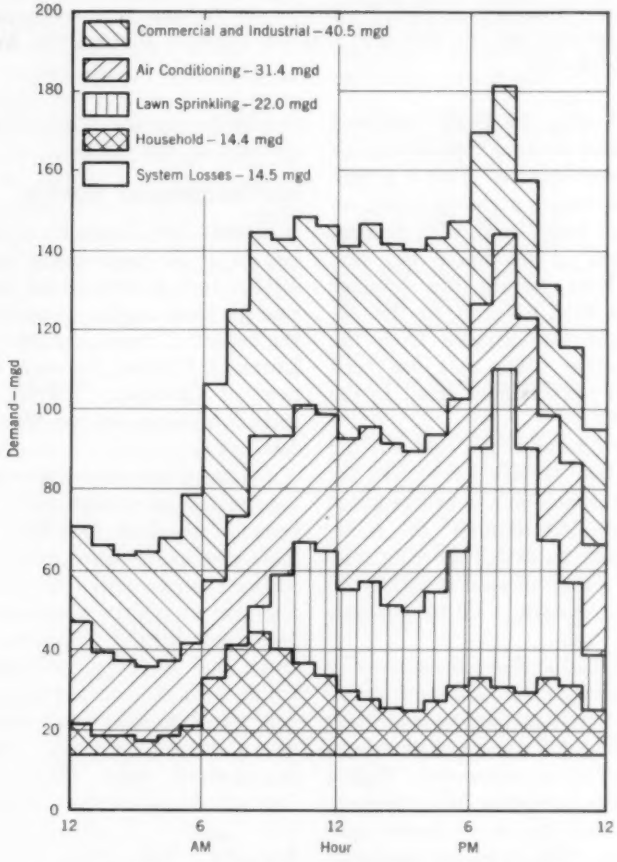

Fig. 1. Kansas City, Mo., Consumption, Jul. 12, 1954

The total consumption for the day, excluding suburban and flowing demands, was 122.8 mil gal.

use restrictions threatened in 1954, Kansas City adopted an ordinance providing that new air-conditioning installations should include conservation devices. The trend in the installation of air-conditioning service in Kansas City was changed by that ordinance. The result is shown in Fig. 3.

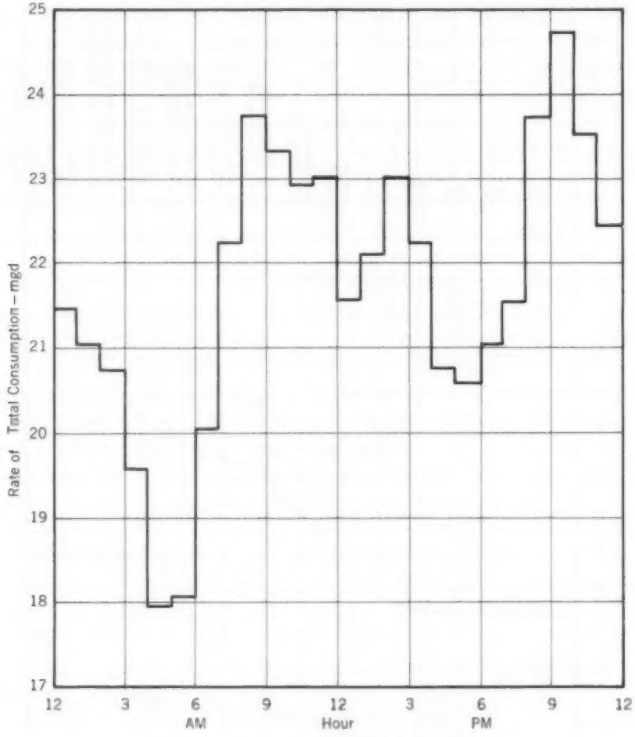

Fig. 2. Suburban Hourly Demand

The demand on Aug. 31, 1953, totaled 22,653,600 gal.

In a rate report presented in the early part of 1956, the Kansas City, Mo., Water Department recommended demand rates for the existing nonconserved air conditioning of $20 per ton per season for commercial installations, and $9.60 per ton per season for residential installations, the difference being accounted for by the variation in water costs between these two classes of service. These rates were not adopted, presumably on the basis that the present nonconserved air-conditioning equipment would go out of service because of obsolescence before it would otherwise contribute to the need for more water system capacity.

The demand charge rate (a charge per ton per season exclusive of water used) is gaining favor as a way of insuring a proper revenue from water

used for air-conditioning service. The following rates of this type are in use: Omaha, Neb.—$36; St. Louis County Water Company—$40; Detroit—$7.50; Appleton City, Wis.—$20; and Pine Bluff, Ark.—$12.50. A rate of $20.00 per ton per season has also been recommended to the Wisconsin Public Service Commission for use in Milwaukee. It should be noted from these examples that the rate plan has had the approval of the state public service commissions in Missouri, Arkansas, and Wisconsin.

A handy way of measuring the concentration of air-conditioning equipment in any community is by tons of

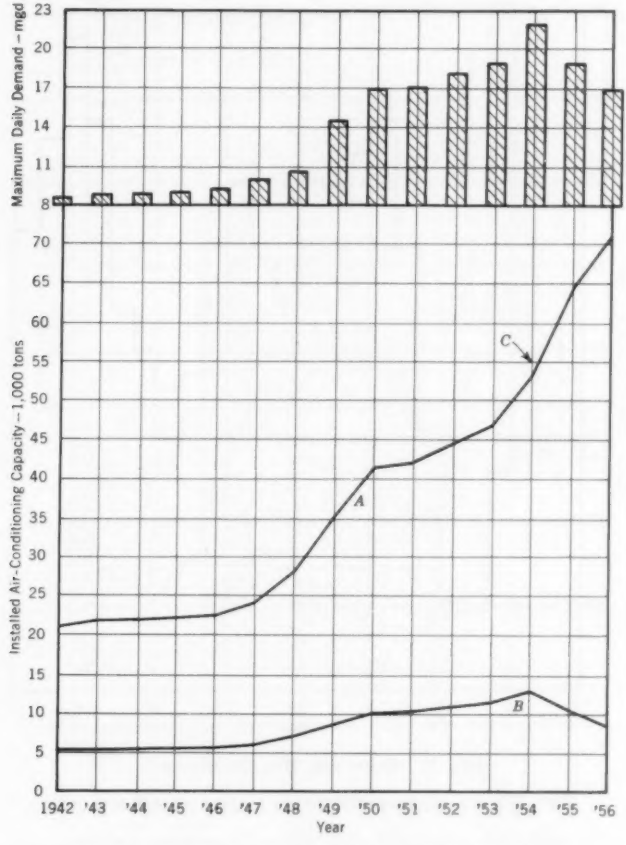

Fig. 3. Trends in Water-Cooled Air Conditioning

Curve A *represents total air-conditioning tonnage, and Curve* B, *total nonconserved air-conditioning tonnage. Point* C *is the date when a city ordinance prohibiting the further installation of nonconserved equipment was passed (Jul. 30, 1954). The upper diagram shows the estimated maximum daily water demand for all air conditioning for the years shown.*

installed capacity per 1,000 population. For certain cities the concentrations of nonconserved air-conditioning equipment in 1956 was: Omaha—71 tons; Detroit—44 tons; Chicago—60 tons; Milwaukee—60 tons; and Kansas City —17 tons.

Residential Service

On Dec. 1, 1951, after approximately 30 years of service under a step or block type of rate for both residential and commercial service, Kansas City initiated a new rate plan. The revised plan effected a separation of the rates for these two main classes of service. A main part of the plan was that the commodity charge for residential service included only a single rate rather than blocks or steps.

The plan, explained elsewhere (*3*), took stock of the three principal characteristics of residential service: [1] household usage averaging 150 gpd; [2] lawn sprinkling; and [3] air-conditioning service. The last two have a very unfavorable load factor, that is, a higher ratio of maximum to average day consumption for the year, so that these services are quite expensive. Household service has a good yearly load factor, but its cost per gallon becomes high when the costs of meter reading and collecting are included. Therefore all residential service is expensive and should bear a high rate.

Commercial Service

If residential service is properly priced, commercial service will be priced much lower. In Kansas City, residential service now costs 27 cents per 100 cu ft, and the average return from a block rate with a service charge for commercial service results in a yearly revenue averaging 15.3 cents per 100 cu ft. The calculations of the costs of these two classes of service are quite dependable. Kansas City has developed considerable evidence of the load factor and the amount of water used for lawn sprinkling (*4*).

The water rate analyst therefore has a way of accounting in rates for the load factor of all residential service including lawn sprinkling and all air-conditioning service. The remainder of the service is accounted for by normal commercial and industrial consumption.

An AWWA committee proposed, in 1950, demand meters for air-conditioning service (*5*). The author believes that the demand charge per ton per season will prove to be more acceptable in most cases. He also believes, however, that the two-part demand rate would be a satisfactory substitute, and that the two-part rate may be the ultimate solution of the problem of equity of regular commercial and industrial service.

In anticipation of the possible need for a two-part rate for commercial service in Kansas City, the author made a survey in the summer of 1956 accounting for approximately 30 per cent of all commercial consumption. The survey included daily meter readings on days of maximum system demand. The results are shown in Fig. 4. The data collected may fall short of perfect representation in that demands for the system were down to 120 mgd from a high of 154 mgd in 1954. The data, however, are thought to reflect fair evidence of what to expect from the application of a two-part rate, in view of the fact that commercial consumers in Kansas City still account for about 8,500 tons of nonconserved air conditioning.

The change in the value of service as affected by load factor is also shown

in Fig. 4. This cost information is derived from a recent water rate report. It should be noted that there is a variation of 40 per cent in the value of service in a load-factor range covering 95 per cent of the consumption. In other words, service to the customer having a 2.40 ratio for maximum to average day is worth 40 per cent more than the service to the customer with a 1.06 ratio. This is a matter of considerable consequence to the customer having the better load factor. He may, in time, begin to insist that the cost of his water service reflect a proper credit for that good load factor. A very small

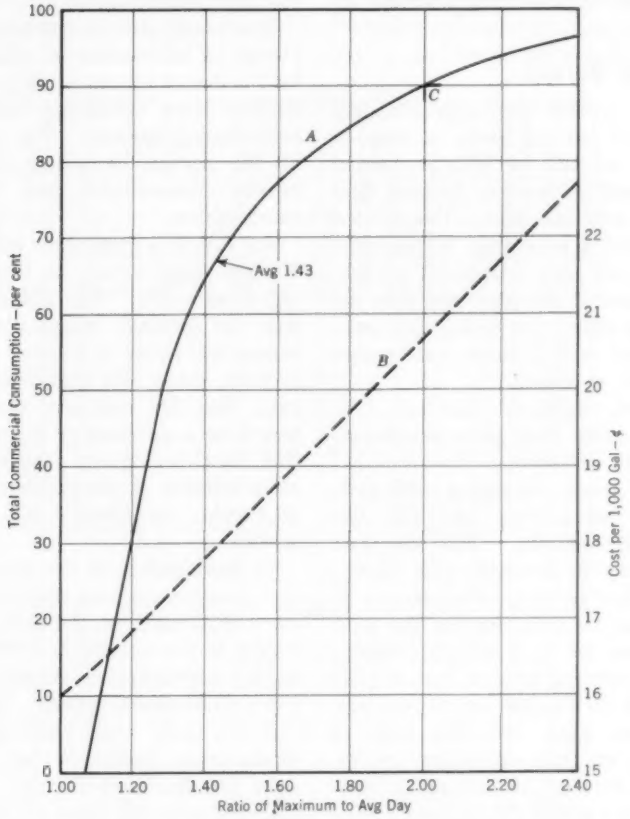

Fig. 4. Yearly Load Factor for Commercial Water Service

Curve A *represents the percentage of total consumption in relation to the ratio of maximum to average day. At Point* C, *for example, 90 per cent of the total consumption has a maximum-to-average day ratio of 2.00 or less. Curve* B *represents the proper cost of service in cents per 1,000 gal.*

percentage of total consumption was found to have a ratio as high as 5.00 to 1.00.

It should be noted also that 50 out of a total of 15,000 consumers accounted for 30 per cent of total consumption, thus making logical a demand rate for larger consumers only. By proceeding in steps from the largest to the smallest meters, the water works industry may approach the problems of complete coverage in gradual stages. Another conclusion drawn from the figures is that demand metering for large customers accounting for a greater part of any system's total consumption is also logical.

Progress in this field will await the development of suitable metering equipment. In its suburban demand rate practice, Kansas City depends on recorders that must be changed daily. These readings need be taken however only in the summer months. The recorder must effect a compromise between chart time and accuracy—certainly chart time should not be less than 7 days.

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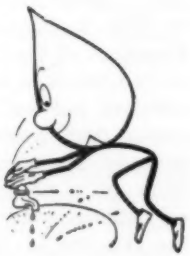

National and Local Aspects of Water Resources Problems

Henry B. Holmes Jr.

A paper presented on Nov. 8, 1956, at the Virginia Section Meeting, Old Point Comfort, Va., by H. B. Holmes Jr., Comr., Div. of Water Resources, Commonwealth of Virginia, Richmond, Va.

ALTHOUGH it has been somewhat spasmodic and scattered, there is evidence of early interest in water resources development other than for purposes of navigation. As far back as 1867, the Wisconsin state legislature appointed a committee to study management of watersheds. Others followed suit and the area of similar state and federal interest expanded as the passage of time dictated the advisability of knowing more and doing something about the wise use and intelligent development of water.

It might be well to engage in a little self-analysis to see whether the things which are being done today are consistent with reasonable provision and the desires of those who will be affected.

Federal Viewpoint

First to be considered is the federal viewpoint which is well represented insofar as presentation of ideas is concerned. In December 1949, Engineers Joint Council sent a communication (*1*) to John R. Steelman, assistant to the President of the United States, telling of its interest in the development of an adequate national policy for water resource development and of the EJC's proposal for action by the establishment of a congressional commission on national water policy. This led to the creation by President Truman of a temporary Water Resources Policy Commission of seven members—the Cooke Commission—which held its first meeting on Jan. 14, 1950. The commission offered an opportunity for all interested parties to bring to its attention their conception of the elements of a sound water resources policy. After a thorough study, EJC submitted to the commission a statement of desirable national water policy in June 1950. The first of three volumes of the Cooke Commission report (*2*) was sent to the President on Dec. 11, 1950. The report was reviewed by each of the nine task committees of the EJC panel which informed the EJC that "there was a unanimous finding that, while certain recommendations of the President's commission were acceptable, nevertheless, the underlying philosophy of this report was so radically different from that expressed in our June 1950 statement that the two documents are, in general, incompatible." Much more time could be devoted to the Cooke report were it not for the fact that reference should be made to three subsequent reports.

Kestnbaum Commission

Some of the remarks and recommendations (*3*) made in June 1955 by the Kestnbaum Commission (Commission on Intergovernmental Relations)

deserve mention. Its first recommendation was "that Congress enact legislation that will define unmistakably the respective rights and responsibilities of the federal and state governments with respect to the inland waters of the country, with a view to maintaining the integrity both of state water laws and of federal control over interstate commerce." In the discussion of the basis for this recommendation, the report relates how states have consistently taken the position that certain federal acts surrendered and relinquished to the states whatever rights the federal government may have had to control the use of the water of non-navigable streams, and how, in a number of lawsuits, the doctrine of paramount rights of the United States to inland waters has been asserted by the Department of Justice. It states:

> Up to the present time, the decisions rendered in such suits have been based on grounds other than the paramount rights doctrine, and in a number of instances the doctrine has been merely asserted but not pressed by the Department of Justice. While it is believed that existing law and decisions of the federal courts are in opposition to such doctrine, its continued assertion by the Department of Justice is the cause of considerable unrest where water for irrigation and domestic uses is a vital necessity. . . . The situation is further confused in many instances where states have neglected to assert their jurisdiction. The failure of these states to promptly assume their responsibilities creates a vacuum into which the federal government tends to rush, thus unbalancing intergovernmental relationships.

If the last part of the above statement is valid, it is probably due to the fact that governmental agencies are made up of, operated by, and subject to the frailties of human beings. The Commission on Intergovernmental Relations also stated:

> . . . that states and local agencies should have a major voice in determining the necessity or advisability of water development projects proposed by the federal government, and that comments submitted by state and local agencies be given serious consideration by the federal agencies and the Congress. [This has been required for Corps of Engineer projects since 1944.—AUTHOR.] The Committee further recommends that, prior to authorization of a project by Congress, a definite attempt be made to harmonize any differences of opinion that may exist between the states and the federal government.

As far as is known Congress (since 1944) has never approved a federal project in Virginia in which the governor did not concur.

These selected passages are mentioned in the hope that many who are dedicated to water will obtain copies of this and subsequent reports and read them in order to understand the processes by which the members of the various commissions arrive at their conclusions, and the reasoning which underlies their recommendations. One of the four "guiding principles" of the Kestnbaum report was "that the national interest is not necessarily best promoted by federal action, and that state and local action is to be preferred whenever it may be expected to give satisfactory results." In studying any of these reports they should be considered in their entirety rather than on a piecemeal basis as is being done here.

Hoover Commission

One of the task forces of the second Hoover Commission was assigned the subject of water resources and power. It had 25 members, six consultants, and

a large professional staff. Ben Moreell —now chairman of the board of directors of the Jones, Laughlin Steel Corporation—was the chairman of the task force. It was subdivided into four task *groups*: one on power generation and distribution, one on reclamation and water supply, one on flood control, and another on improvements to navigation.

The task force reports (*4*) that "the most difficult problem of water resources development is the balancing of the interests, demands, and responsibilities of individuals, local groups, states, and the federal government." Under the heading of overlapping federal agencies, it is rather startling to read that twelve are concerned with flood damage abatement; nine with irrigation; eight with drainage; seven with improvements to navigation; nine with pollution control; ten with watershed treatment; ten with recreation, fish, and wildlife conservation; nine with power transmission and distribution; fifteen with power generation; and thirteen with water supply. Of course, most of them appear in more than one of the above categories.

The report to Congress (June 1955) goes on to indicate some of the weaknesses in the methods of determining benefits from and the justification of projects, and refers to excessive estimates of benefits, including those from flood control. With no intent of casting doubt upon the competence of the federal agencies concerned with water development, several examples are included as specific illustrations. Most of these illustrations could be explained by errors in either judgment or computation—examples of what is liable to happen, accidentally or intentionally, when people do things.

Five other problems common to all branches of water development are listed and discussed briefly. They are:

1. The adequate gathering of basic hydrologic data
2. The adequate division of the costs of multipurpose dams between power and irrigation, which make some return to the government, and navigation and flood control, which make no return
3. The priority of domestic water over all other uses
4. Pollution
5. Coordination of basin development.

A recent (Oct. 21, 1956) article in a Richmond, Va., newspaper indicated that 60 per cent of the water resources recommendations had been marked "not acceptable" or left for future decision by the administration.

Without attempting to discuss the recommendations concerning water resources and power, it will be appropriate to refer to some of the remarks made by task force members at a conference on national water and power policy in St. Louis in January 1956—6 months after the report (*5*) was submitted to Congress.

This conference was sponsored by the Chamber of Commerce of the United States, Engineers Joint Council, and the National Water Conservation Conference. Ben Moreell, already mentioned as chairman of the Task Force on Water Resources and Power of the Hoover Commission, spoke to the conference on the recommendations made by that task force. After pointing out the difference between a national water policy, applicable to all waters and all users in the nation, and a federal water policy, applicable to the proper functions of the federal government, he called attention to the inconsistency of federal policies as they pertain to irrigation, flood control, naviga-

tion, and power. The Federal Power Act of 1920 brought some degree of uniformity in the power policy, although, about 5 years ago, another federal agency injected itself into the Federal Power Commission action on the Virginia Electric & Power Company's application for authority to build the Roanoke Rapids project on the Roanoke River.

Other independent federal policies have grown up in the fields of water supply, recreation, pollution control, fish and wildlife conservation, and water flow retardation. Naturally there was an expressed need for a major overhaul of this hodgepodge of individual and uncoordinated federal policies. Those who take part in this overhaul should not overlook the increasing and rapid transfer of political, economic, and social power from the states to the federal government, with its resultant danger to the structure of our republican form of government. With respect to the comment in the Kestnbaum Report concerning the tendency of the federal government to rush into the vacuum created by the failure of states to assume their responsibilities promptly, Moreell said:

> Concern that necessary water resource developments will not be accomplished unless they are undertaken by the federal government is based on false assumptions and is encouraged primarily by those seeking power and favor through the distribution of funds derived from other people's taxes.

There are many who agree with this viewpoint.

In referring to the matters of federal "subsidies" he further stated that it amounts to 98 per cent for navigation, 94 per cent for flood control, 73 per cent for irrigation, and about 40 per cent for power. Some of these can hardly be called partnership undertakings.

Moreell states the three objectives of the task force recommendations as follows:

1. To define a consistent federal policy for water resource and power development to the end that centralization of authority in the federal government should be lessened, local authority and participation strengthened, and competition with private enterprise eliminated.

2. To assure that consistent and sound principles and criteria be applied to determine what projects involving the federal interest would increase the national wealth, and to determine whether or not state and local interests are willing to assume financial and administrative responsibility commensurate with the benefits they receive.

3. To strengthen congressional control over water resources and power programs by establishing a central responsibility and authority that would enforce consistent policies and assure the technical soundness, the economic justification, and the financial feasibility of plans and projects proposed by the various agencies and by local entities.

An amplification of No. 3 above might clarify the amount of congressional control and enforcement contemplated for plans and projects proposed by local entities. It is difficult for the average individual to keep constantly before him the fact that the closer we keep our governmental functions to the people, the better will be the results. There are many indications that the more detached a public official is from the grass roots the harder it is for him to retain a clear concept of his true mission.

The conference on national water and power policy in St. Louis last January was also addressed by each of

the chairmen of the four task groups of the Task Force on Water Resources and Power. Wesley W. Horner of St. Louis, chairman of the group on flood control, expressed the view that too large a percentage of the cost of the abatement of flood damage is borne by the federal government and estimated the total cost of a long-range program under the Flood Control Act and the Watershed Protection Act as some 90 billion dollars—one fourth of the present national debt. He felt that there is too little investigation of alternate means of reducing flood damage, that economically justified projects should be less expensive, and that local and regional agencies (as opposed to federal agencies) should provide a considerable portion of the funds.

Carey H. Brown, of Scottsville, N.Y., chairman of the group on navigation, spoke of the inadequate criteria by which navigation improvements are judged, the tendency to overestimate benefits and underestimate costs, and the probability that payment of tolls commensurate with the use of the facilities might discourage the promotion of new projects of dubious worth.

John Jirgal of Chicago advocated the sale of the present federal hydroelectric properties, insofar as possible, to either public or private interests. He also believes that the Federal Power Commission should be the only federal agency dealing with regulatory jurisdiction over rates, accounts, and cost allocations of federal power agencies, as well as the allocation of power among states.

Presidential Advisory Committee

The latest report (*6*) on the federal level is that from The Presidential Advisory Committee consisting of the Secretaries of the Interior, Defense, and Agriculture. It was submitted on Dec. 22, 1955 and, in January 1956, was sent to the House and Senate by President Eisenhower who said in part:

> The policies set out in the report embody a framework within which the federal government, with state and local governments and other nonfederal interests, may operate to develop our water resources. . . . The policies we adopt for the development of our water resources will have a profound effect in the years to come upon our domestic, agricultural, and industrial economy. I commend the fundamental purposes and objectives of this report, and I earnestly recommend that the Congress give prompt attention to its proposals.

In its summary, the committee stated:

> A sound water policy must look toward an adequate supply of water for our people, prevent waste, reduce water pollution to its lowest practicable level, provide means for the best and most effective distribution of water, improve navigation, and take steps to check the destructive forces of water which destroy land, property, and life. There are many different problems in different areas. It is neither practicable nor desirable to have only federal responsibility. There is no single "national" water problem.

The committee also made eight major recommendations. The first pertained to the acceleration of the present program for the collection of basic data, and the second called for the planning of water resources and related development on a cooperative basis, with federal, state, and local agencies participating. Another recommendation proposed an organization plan which would provide for a coordinator of water resources directly under the President, an independent board of review to analyze projects from an engineering and economic

angle, river basin resources committees, and a permanent federal interagency committee under the coordinator.

In its fourth recommendation the committee advocated recognition of the concept that water rights are property rights and that there be a study to determine the relationships between those rights and the social and economic development of the nation and the area. Another part of the water rights recommendation concerned the enactment by states of legislation regarding the ownership of underground water, and the formation of interstate compacts where appropriate. In its fifth recommendation, reference is made to the obvious fact that no system of relative priorities should be applied uniformly to the entire country. Another recommendation pertained to the desirability of a uniform basis for the evaluation of water projects, and separate authorization by Congress of each major water resources project was advocated. The last major recommendation dealt with the partnership concept and contemplated the sharing of costs in accordance with the measure of the benefits of a particular project.

In discussing the river basin committees, there is a statement to the effect that "the membership of the committees should include one representative of each federal department having water resource responsibilities . . . and one qualified representative of each affected state . . . all on an equal basis." The second sentence after that reads: "The total number of either federal or state representatives is regarded as immaterial, since the conflicts should be resolved by cooperation and not by voting strength." People, however, are not so constituted.

These brief references to portions of important reports give some indications of the water resources problems when viewed from the federal level. They pertain to both *national* aspects and *federal* aspects which are not synonymous.

[Since this article was written, new statements on national water policy have been prepared by the AWWA Committee on National Water Policy and the EJC National Water Policy Panel Review Board. These were published in *Willing Water* No. 45.—Ed.]

State and Local Activities

There are many questions concerning water resources to which satisfactory answers cannot be found in the legal codes. Apparently, needs have been met as they arose. Search of the constitution of Virginia discloses only two sections in which reference is made to water resources. This is not surprising, for that document, unlike the federal constitution which grants powers, is a restraining instrument which prohibits certain acts by the general assembly. On May 6, 1776, at Williamsburg, Va., an ordinance was enacted by the general convention which established the common law of England as the "rule of decision" for the colony under certain conditions. The provisions of that ordinance are still in the legal code in the following language:

> The common law of England, insofar as it is not repugnant to the principles of the Bill of Rights and the constitution of this state, shall continue in full force within the same, and be the rule of decision, except as altered by the general assembly.

Over the years, the common law of England has been the "rule of decision" in cases pertaining to water just as it has in cases pertaining to other subjects. In the making of decisions,

the courts of Virginia have adopted the broad principles of the so-called riparian doctrine which, in essence, means that an owner of riparian land is entitled to the use of the natural flow of the water in watercourses as concerns both its quality and quantity.

In one decision (*7*) the court said in part:

> All riparian proprietors have an equal right to use the water, and each must exercise his right in a reasonable manner and to a reasonable extent, so as not to interfere unnecessarily with the corresponding rights of others. Exclusive rights in the flow of the stream cannot be acquired by mere priority of use. There is no fixed rule for determining what will constitute a reasonable use; each case depends upon its own peculiar facts, and this is usually a question of fact to be submitted to, and determined by, a jury.

Another decision (*8*) of great interest is one rendered by the US Supreme Court which said in substance that a state may change the common law rule and permit the appropriation of the flowing waters for such purposes as it deems wise. This was subject to two limitations: "the superior power of the general government to secure the uninterrupted navigability of all navigable streams within the limits of the United States," and the riparian rights incident to property owned by the federal government. Note that, basically, this is in keeping with the 1776 ordinance which retained the common law "until the same shall be altered by the legislative power of this colony."

Early American cases concerning ground water followed the common law, under which the fee-simple owner of land could make use of the underlying percolating ground water as he pleased even to the extent of cutting it off maliciously. The trend of modern opinion, however, is in favor of the reasonable-use rule which has come to be called the American rule.

From time to time, Virginia's general assembly has deemed it wise to alter the common law and to give statutory authority for uses of water. Probably the oldest authority is that delegated under the Mill Dam Act. Another use specified in the legal code is for the generation of hydroelectric power. A third, included in many municipal charters, pertains to water supplies for cities and towns. Also there are those statutes pertaining to the responsibilities of the health department in the matter of public water supply systems, and the 1946 Water Control Law which extends legal controls in this area.

Thus, points of law concerning water may be covered by statute or by court decisions. Before the 1956 session of the general assembly, all of these followed the riparian doctrine very closely. It appears, however, that authoritative court decisions have failed to develop the riparian doctrine completely in Virginia. It is difficult to find any definite pronouncements on the artificial use of water for irrigation. Artificial use in industry has been defined almost entirely on the basis of power or quality. Also, there is little to be found on the subject of conservation which, as used here, means wise use and intelligent development.

Recent Legislation

Some background information concerning recent legislation in the water resources field may be of interest.

Of seventeen committees appointed by the Advisory Council on the Virginia Economy, one devoted its efforts to the subject of water resources. As

the result of one of the recommendations of that committee (*9*), the Virginia Advisory Legislative Council was asked to study matters pertaining to water resources and make appropriate recommendations to the governor and to the general assembly. The first concrete action by the general assembly based on the VALC study (*10*), was at its 1954 session when it fixed and declared the policy of the state in regard to certain waters:

> (b) The regulation, control, development, and use of waters for all purposes beneficial to the public are within the jurisdiction of the state which, in the exercise of its police powers, may establish measures to effectuate the proper and comprehensive utilization and protection of such waters.

Also at the 1954 session, the VALC was charged with further study of water resources. The VALC Water Resources Committee, under Chairman John H. Daniel of Charlotte Court House, Va., devoted its attention during the 1954–1956 period primarily to matters pertaining to surface waters. It held public hearings at eight places throughout the state and those who spoke at these hearings assisted greatly in the committee's efforts.

Some of the statements made at the hearings convinced the members that one piece of legislation concerning ground water was needed promptly. As a consequence, a 1956 act of the general assembly requires the capping of wild-flowing artesian wells which, in their present condition, are dissipating artesian pressures needlessly. This is particularly true in the tidewater area.

Another piece of water legislation passed by the 1956 general assembly authorizes a deviation from a strict interpretation of the riparian doctrine. This was recommended by the VALC because the hearings indicated clearly that many people throughout the state were interested in having some authority for the capture of waters during times of plenty so that they could be used to meet their needs during times of drought. Substantially that is what the 1956 impoundment law authorizes. Thus the general assembly has accepted, in principle, a beneficial deviation from a strict interpretation of the riparian doctrine under which all waters whether they be flood flows, average flows, or base flows, are to be available for reasonable use by all riparian owners. This acceptance is wise, for few, if any, riparian owners are desirous of having flood flows and it is sound conservation practice to make some use of these flood waters which are doing no good. Provision is made for "the sole and unrestricted use of the flood waters thus stored for the purpose for which the storage was authorized." There is no restriction on the purposes to be stated in the petition for authority to build an impounding structure.

Undoubtedly experience will dictate some changes in the law, but it is probable that the basic principle will remain in being. It is sound.

Conclusions

There was no thought that these two recent pieces of legislation are all that can be beneficial to Virginia. Perhaps no other bills on the subject were introduced for two reasons: they may not be needed today, and the people may not be ready to accept them. An idea in the mind of one individual is not a sufficient basis for new water legislation. The idea may be perfect, but until people understand it and are

ready to accept it, there is little chance of its adoption.

That fact raises what might be considered the prime problem concerning water resources—the general lack of correct information about water resources. The obvious solution is the dissemination of correct information. In some cases it will be necessary to await opportunities—one cannot simply barge into a meeting and say "I want to tell you about water." In other instances, the approach may be more direct. Circumstances will govern the steps to be taken. It is necessary to remember at all times that an informed public makes few mistakes and is willing to take action when the time comes.

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Water Law in Eastern United States

A Symposium

The problem of the conservation and equitable distribution of water becomes more acute as local supplies continue to diminish and consumption increases. Existing water law is often inadequate for modern conditions and there is a growing need for new or revised legislation. This symposium presents some of the viewpoints on these problems and reports on the status of water legislation in some eastern states. For a review of legislation in Virginia, see pages 717–720 of preceding article.

North Carolina and Other Atlantic States

Claude L. Love

A paper presented on Nov. 13, 1956, at the North Carolina Section Meeting, Charlotte, N.C., by Claude L. Love, Asst. Attorney General, Raleigh, N.C.

WATER is, in the nature of things, not capable of absolute ownership. The problem is put very well in the early Connecticut case of *Mitchell* v. *Warner* (*1*) where it was stated: "Water is neither land nor tenement, nor susceptible of absolute ownership. It is a movable, wandering thing, and must, of necessity, continue common by the law of nature. It admits only of a transient, usufructuary property." Because of this inherent characteristic of water, the problems which arise concerning it are problems of use.

The nature of the problems was early recognized by the North Carolina Supreme Court in the case of *Pugh* v. *Wheeler* (*2*), where the court declared: "The question is, in any state of the stream, whether a person owning land on it, and thereby entitled to certain beneficial uses of the water, has been deprived, by means of the acts of another, of some of those uses which, but for those acts, he would enjoy in that particular state of the stream. If so, he has sustained some injury, and is entitled to recover the damages."

Water Use Doctrines

Generally speaking, there are two doctrines which govern the use of water in the United States. These doctrines are the riparian doctrine and the appropriations doctrine. The riparian doctrine reserves the right to the use of water to the owners of land contiguous to the watercourse. Under this doctrine, such a landowner has the right to have a stream which flows by or through his land continue its course undiminished in quantity, with the exception that any riparian owner may make whatever use of the water he needs for domestic and household purposes and for watering farm animals. The appropriations doctrine, on the other hand, allows the person who first appropriates water to a beneficial use to continue to use the water to the ex-

tent of his appropriation or to the extent of his need—whichever is the smaller.

The appropriations doctrine is in effect in the seventeen western states of the United States and the riparian doctrine is in force in the 31 eastern states. Since the riparian doctrine emphasizes the right to use water in common without regard to quantity, time or place, but subject only to the rule of reasonable use, and the appropriations doctrine emphasizes rights of exclusive use for specific quantities, times and places, it is altogether natural that the appropriations doctrine early took strong hold in the western part of the United States because of the limited water supply. The eastern states have, until recent years, composed a region of excess water supply and, therefore, could afford the luxury of the riparian doctrine.

All of the states in the southeastern part of the United States follow the general rule of riparian rights. These states have enacted little legislation in this field. As a matter of fact, the only legislation governing water use is a Georgia statute, which states the general rule of riparian rights and then adds: ". . . and the diverting of the stream wholly or in part . . . or the obstructing thereof so as to impede its course or cause it to overflow or injure his land, or any right appurtenant thereto, or the pollution thereof so as to lessen its value to him, shall be a trespass upon his property."

New England States

The New England states also follow the riparian doctrine. As might be expected, however, the more highly developed industrial system in New England has produced more water legislation than has been enacted in the southeastern part of the United States. Even in New England, however, most of the states have not gone very far in the statutory regulation of water use.

In Massachusetts, a state planning board has been created to prepare a master plan for the development of Massachusetts and for the allocation of land for water conservation.

In Maine, more has been done. There, a statute exists which allows a riparian owner to divert water upon filing a petition asking that he be allowed to do so. This right may be restricted by the verdict of a jury. Furthermore, any person whose lands are damaged by the diversion of water may recover damages, and persons are prohibited from constructing watercourses which would inconvenience any person in the use of his house or building or interfere with the prosecution of his business. Maine also requires that before a dam is erected to develop water power or to control the water of any stream or lake, copies of the proposed construction plans must be filed with the Public Utilities Commission.

Connecticut prohibits all persons from building a dam or obstructing a watercourse to the special damage of any person, and a violation of this prohibition constitutes an abatable nuisance as well as a penal offense. Connecticut has created a state agency to supervise dams, dikes, reservoirs, and similar structures. This agency may investigate and inspect all structures of this character and order the owner of any unsafe structure either to render it safe or to remove it. Before this type of structure may be built, altered, added to, or removed by any person, a permit to undertake the project must be obtained from the state agency. Such a permit will be issued only after the agency has examined and approved the site and the plans and specifications for

the structure. Even after a permit has been issued, the agency must inspect the work to see that the structure will be safe, and it may place an inspector on the job. If a dam or similar structure is built or maintained without acquiring the necessary permit, or if orders of the agency relative to the maintenance, repair, or removal of the structure are not complied with, the persons responsible may be heavily fined and an action may be brought to enjoin its use. Persons aggrieved by the decision of the agency are entitled to a hearing before it and may thereafter appeal to the courts. In addition to these statutes relating to the safety of dams, no person may obstruct a stream so as to prevent the passing of fish unless he is authorized to do so by the Superintendent of the State Board of Fisheries.

Under the laws of Vermont, authorization must be obtained from the Public Service Commission before a dam which impounds more than 500,000 cu ft of water is constructed. To obtain this authorization, an application must be made to the commission, setting forth the proposed location of the dam and its dimensions. When such an application is received, the commission holds a hearing in the vicinity where the dam is to be constructed after giving notice to all interested parties. At this hearing the commission determines whether the proposed construction is for the benefit of the people of Vermont. If the commission finds an existing dam to be unsafe, it may order that it be repaired or removed. Violation, disobedience, or failure to comply with any order or judgment of the commission renders the person involved subject to a fine of up to $5,000. Finally, any person aggrieved by an act or order of the commission may go before the supreme court of Vermont.

Rhode Island's only statute on water use is one which prohibits a person who owns a dam on a stream from detaining the natural flow of the stream for more than 12 out of each 24 hours. This prohibition, however, is not applicable unless the owner of the dam has been requested by another owner of a dam within one mile below him on the same stream to allow the natural flow to pass downstream.

New Hampshire has gone much further in the statutory regulation of the use of water than any of the New England or southeastern states. It has declared that there is a need in that state for the conservation and distribution of water and the regulation of the flow of rivers and streams in order to promote the state's industrial and economic welfare. To meet this need the New Hampshire Water Resources Board was created. The board may construct reservoirs, dams, canals, lateral ditches, pumping outlets, mains, pipelines, water works systems, and similar installations to carry out its broad purposes. In carrying out its functions, the board may use and control all public waters and all waters in which the state owns water rights. Before beginning a project the board must obtain a determination by the governor and his council that the project is within the authority of the board and that it will be of public use and benefit. When this approval has been received the board must proceed to make contracts with persons or corporations who will be specifically benefited by the project in order to have these users pay for the benefits they will receive. If a user of water who will be substantially benefited by the project refuses to enter into a contract with the

board, or if there is disagreement over the amount to be paid by a particular user, the dispute may be presented to the courts for determination. New Hampshire has, in addition to the water resources board, a water control commission. The commission attempts to minimize damage to property from stream flow at times of high water by conferences with dam owners and by regulation of the erection and maintenance of dams. The commission also has broad power which is of an interesting type: It may investigate conditions affecting the use and enjoyment of any inland public water, and, if it appears after investigation that the outlet of the water is managed in such a way as to affect seriously and adversely the value of shore property above the outlet or riparian rights below it, the commission may recommend changes in the management of the water outlet. When a report of this type of mismanagement is made to the attorney general, he institutes proceedings in equity in the superior court in order to protect the rights of the persons affected.

North Carolina Practice

In North Carolina at the present time, watercourses are divided into three classifications: [1] coastal bays and inlets and other waters which can be navigated by seagoing vessels; [2] other watercourses capable of being navigated by boats, flats, and rafts; and [3] rivulets, brooks, and other streams which for any reason cannot be used for inland navigation.

The waters in Class 1 are navigable waters and are altogether public in character. Hence, neither they nor the soil under them can be entered by or granted to private persons.

Waters in Class 2 are technically nonnavigable, and title to them may be acquired by individuals. If the grant includes the bed of such a stream, the owner may place a dam in the stream, a thing which, perhaps, could not be done by a mere riparian owner. But if a person does not have title to the bed of such a stream, he simply has an incidental easement in it which he may exercise in a manner compatible with the right which the public has in the stream. The extent of this easement and the manner in which it may be enjoyed may be regulated by statute.

All waters in Class 3 may be owned absolutely by private persons. Incident to this absolute ownership, the owners may make any use of the waters which they consider desirable, such as for fishing, milling, or some other lawful trade or business. There is, however, one restriction upon the use which owners of these waters may make of them: each owner must so use the water on his property that he does not interfere with the similar rights of other property owners above and below him on the same stream. (The restrictions of this classification were sanctioned by the decision in *State* v. *Glen* (*3*).

Obviously, the state may regulate the use of waters in Class 1. If a watercourse is in Class 2 the state may regulate the use of the stream but it must be careful not to interfere with property rights of landowners. In the case (*3*) above, the court held that where a person had title to land on both sides of a stream and to the bed of the stream he could build a dam on the stream bed. It held further that the owner could not be deprived of this right to erect the dam except for a public purpose and upon just compensation. The same reasoning would seem to apply to

waters in Class 3, but here, also, it would seem that the state could exercise some power of regulation on the theory that it was determining the extent to which water rights of other riparian owners are to be protected.

The riparian doctrine does not mean that no water may be diverted from a stream. In *Smith* v. *Morganton* (*4*), the court held that a riparian owner may not take so much water from a stream that he materially injures those riparian owners below him. (See also, *Harris* v. *Railroad* (*5*). Of course, whether there is a material injury depends somewhat upon whether a particular use is reasonable, and both of these factors are determined by the circumstances of each case.

It is clear that it is not unreasonable for a railroad riparian owner to take a part of the flow of the stream for use in its locomotives. Furthermore, it was established in *Dunlap* v. *Carolina Power & Light Co.* (*6*) that it is not unreasonable for a power company to erect a dam in a stream for the purpose of generating electricity, even if this results in the diminution of the flow of the stream at certain times during each day.

On the other hand, it is just as clear that a city cannot impound the waters of a stream for use by its citizens as a water supply, because in doing this the city is not exercising the right of a riparian owner to make reasonable use of water (*7*).

The question of reasonable use is subject to an infinite variety of situations and interpretations. Under the present law, if a person proceeds to divert water from a stream, his right to do so may be challenged and he may be required either to cease the diversion or respond in damages or both if a court should determine that his use is not a reasonable one. This uncertainty was tolerable when the economy was predominantly agricultural and most of the water uses were for natural purposes. Now that the economy is becoming greatly industrialized there is a growing need for certainty in the right to use water.

North Carolina has only one statute relating to the *use* of water. It requires that a permit be obtained from the Director of the Department of Conservation and Development before utilizing (for irrigation) waters from the streams, rivers, creeks, or lakes of North Carolina where the use would reduce substantially the volume or flow. To obtain such a permit, a proposed irrigation plan and survey must be filed with the department, which, after investigation of the plan in the light of safety and public interest, may approve the plan and issue a permit.

Summary

To summarize the results of this preliminary exploration, it may be said that there is little precedent in the statutes of the eastern part of the United States for the regulation of the use of water on anything like the scale which this regulation takes in the western states. This is not surprising in view of the fact that from the very beginning in the eastern states, the demand has not been as great and the supply has been far more plentiful. Although the water supply in the eastern states remains fairly constant, use of water is rapidly increasing as more industries come to North Carolina. The pulp and paper industry, which already has a strong foothold in North Carolina, is one of the leading industrial users of water (*8*).

As the several needs for water increase, the differential between the sup-

ply of water and the need for it will steadily diminish. As this happens, conflicts between competing users of water are bound to arise. These competing interests have not as yet come fully to grips in North Carolina because water is still plentiful in the state. Before these strenuous pressures and conflicts come, it may be well to consider whether it is wise to leave the determination of rights to water use in the present unsettled state. Under current law, these rights are adjudicated by different courts in different parts of North Carolina, in decisions on isolated actions for damages or suits in equity. This method of allocating water rights is haphazard and fortuitous and the obstacle it presents to the economical use of water resources may be a luxury which an industrialized economy cannot afford.

Proposals

One way to allocate water usage would be by giving some administrative agency authority to determine the rights to use water. There are several problems which will arise in the establishment of this type of regulatory system:

1. Some method must be devised to determine present and probable future water resources.

2. Any legislation must, to be constitutional, protect vested property rights. Although rights in water are simply rights in use and do not give those having the right of use any ownership of the corpus of the water itself, the right to use water is a property right which is entitled to protection to the same extent as other forms of property (*9, 10*). This is one reason why there should be early legislation on this point if there is to be legislation on it at all. The longer the delay, the more the vested rights increase and, to a certain extent, limit complete effective regulation.

3. The statute must be so framed as to insure the greatest beneficial use of water resources.

4. Some determination must be made of state policy concerning the extent of and manner in which it desires to protect water resources.

5. The administrative agency should be able to control acquisition of new water rights and to allocate water to riparian owners and to others for artificial uses in agriculture and industry. There should be some method for making application to the agency for a right to use water and provision for a public hearing after notice upon such an application. Perhaps some appeal to the courts should be available from adverse decisions of the agency. There is, of course, the problem of whom should be made parties to such a hearing.

6. A water right when granted should not be absolute; it should be conditioned upon successful application of the water to the approved use within some specified reasonable period of time.

7. The agency should have authority to modify allocations when circumstances and needs have changed. Just how broad this power to modify an allocation should be and what type of changed conditions would justify it are very difficult policy problems which would have to be resolved. It seems clear, however, that any modification of a water right once allocated would have to be surrounded with procedural safeguards to give an allocation once made some degree of permanency. Constitutional difficulties might otherwise arise, and investors and industries would be unwilling to make large expenditures of money on the basis of

an allocation. Probably, the agency should be allowed to modify an allocation only after notice and hearing to all persons affected, and modification should be permissible only if the agency finds on the basis of evidence that the person holding the allocation is not putting to beneficial use the full amount of water allocated to him; that another need has arisen superior in quality to the present allocation; or that another need has arisen equal in quality to the present allocation and whose satisfaction at another source would impose a hardship greater than would modification by the original user. Any person aggrieved by the modification of a water right should be allowed to appeal to the courts.

8. The agency should have some authority to cancel, after notice and hearing, any water allocation not used since it was allotted or whose use has been stopped for a specified time.

A bill introduced in the 1955 session of the North Carolina General Assembly, would have provided for a transition from the riparian doctrine to the appropriation doctrine and created a board of water commissioners with broad powers. The bill defined "vested rights" in water and attempted to protect them. Another bill, introduced later in the session and enacted created a board of water commissioners to make a continuous study of the water resources of the state and to make recommendations to the Governor and to the general assembly on proposed changes in the water law. This act also gives the Governor the authority to declare a water emergency under certain circumstances and provides for certain priorities in the use of water during it.

The state of Mississippi, during the 1956 session of its legislature, passed a rather comprehensive act designed to make a gradual transition from the riparian doctrine to the appropriations doctrine. The principal difference between the Mississippi act and the North Carolina bill mentioned above, is that the Mississippi act provides for an "established average minimum flow" of water in a particular stream and for the appropriation of the water in the stream in excess of that flow.

At the last session of the general assembly of South Carolina, two bills were introduced which contained substantially the same provisions as those in the North Carolina bill. The South Carolina bills, however, were materially amended to provide for an "established average minimum flow" and for the appropriation of the excess only. This amended bill was not passed and will probably be reintroduced at the next session.

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Maryland—*Joseph T. Singewald Jr.*

A paper presented on Oct. 25, 1956, at the Chesapeake Section Meeting, Baltimore, Md., by Joseph T. Singewald Jr., Director, Dept. of Geology, Mines & Water Resources, The Johns Hopkins University, Baltimore, Md.

In 1933, Maryland asserted control over the appropriation or use of surface and underground water in the state "in order to conserve, protect, and utilize the water resources of the state in accordance with the best interests of the people of Maryland." The use of water for domestic and farming purposes, however, was exempted from control.

Resources and Consumption

In 1943, the Department of Geology, Mines and Water Resources began a comprehensive inventory of the water resources of the state. Stream-gaging stations were installed to obtain statewide stream flow coverage with respect to geographic distribution, size of streams, and topographic and geologic features of drainage basins. A systematic inventory of the ground water of the state was inaugurated and has been completed in 21 of the 23 counties. The cost of these water resources investigations has been $1,500,000, divided evenly between Maryland and federal funds.

Water is the only replenishable mineral resource. The magnitude of Maryland's water resources is measured, therefore, by the amount of replenishment. An insufficiency of water resources can exist only when the rate of consumption exceeds the rate of replenishment.

The average annual rainfall in Maryland exceeds 7,000 bil gal. Nature consumes 60 per cent in evapotranspiration, leaving 2,800 bil gal to replenish surface waters and ground waters. Half of this is surface runoff that provides the flood flow of streams. The other half is ground water recharge which overfills the ground water reservoirs and spills out continuously to provide the sustained flow of streams between periods of rainfall.

The highest per capita water consumption in Maryland occurs in Baltimore. Extrapolated to include the entire state, Maryland would need only 190 bil gal of water annually. Compilation of actual consumption data gives a consumption of 40 bil gal of ground water and 110 bil gal of surface water, a total of 150 bil gal a year. This is 5.7 per cent of the rate of replenishment with the other 94.3 per cent discharged to waste into the ocean.

There is no water *resources* problem. The only water problems in Maryland are water *supply* problems. Nature has not made these overabundant water resources available everywhere in the quantity and rate needed and at the time needed.

In the tidewater counties of Maryland, nature has solved all of these water supply problems with its ground water resources—mainly in its artesian aquifers, but also in its water table aquifers. The storage capacity of these water-bearing sands and gravels is enormous and their transmissibility is high, so that wells with sustained yields of hundreds of gallons a minute can be developed. Surface water resources

play a lesser role in the tidewater counties. The soil is so porous that surface runoff is low, and countless tidal estuaries penetrate far inland, so that stream courses above brackish tidal waters are short and streams are not numerous.

In central and western Maryland the rocks are generally impermeable, and water occurs only as water table water in small crevices and openings in the rocks. Transmissibility of the aquifers is low, so that the average yield of wells is less than 15 gpm. Storage is small and becomes depleted when rainfall is deficient, resulting in decrease in yields of wells and even in failure of wells. Storage, however, is replenished immediately by substantial rainfall. On the other hand, surface runoff and ground water overflow into streams are greater than average and stream courses are longer and more numerous. Stream flow is more than 16 in. per acre in the drainage basins. Large and sustained yields of water are obtainable in central and western Maryland from surface waters only. Nature, however, has not provided large storage reservoirs of surface water as she has of ground water in the tidewater counties. Only the water in transit in the stream is available and, during periods of low stream flow, the quantity is inadequate to sustain large yields. Large sustained yields are obtainable only by storing the flood waters in reservoirs behind dams.

Water Uses

Water resources in Maryland are used for: [1] domestic purposes (household uses, watering of farm livestock, and irrigation of home gardens and lawns); [2] supplemental farm irrigation; [3] public water supplies; [4] industrial purposes.

Sustained domestic supplies are available everywhere, generally as ground water, and it is both reasonable and practicable to continue their exemption from control. The domestic user has no water resources problem in Maryland.

Sustained ground water supplies for supplemental irrigation are available throughout the tidewater counties. Control is needed only to protect the aquifers against infiltration of brackish tidal water through improperly located wells, and to protect wells against impairment of yield through overlapping cones of depression resulting from improperly located wells.

In central and western Maryland, large yields must and can be obtained from surface waters, but the surface waters are deficient at the time the yields are needed for supplemental irrigation. Large sustained yields for supplemental irrigation require storage reservoirs. The rights to surface waters are restricted to riparian owners, yet the volume of water in the streams, both as flood flow and as sustained flow from ground water discharge, comes equally—acre for acre—from the total acreage of the drainage basins. The supplemental irrigator in central and western Maryland has two water resources problems—the legal right to water and the financing of storage.

No municipality in Maryland has been unable to find ample water resources. In Tidewater counties the artesian aquifers, and even the water table aquifers, have adequate storage for sustained yields, unaffected by periods of deficient rainfall. In central and western Maryland (regions dependent on surface waters), communities are financially able to provide stor-

age to tide over dry periods of inadequate stream flow.

Water resources are so ample that industries in Maryland have no problem in locating where an adequate water supply can be developed. They can obtain a sustained yield of ground water in the Tidewater counties without the necessity of providing artificial storage, and in central and western Maryland, secure a sustained yield of surface water by providing storage reservoirs behind dams, because low and drought flows may be inadequate.

In Maryland, therefore, only the supplemental irrigator, dependent on surface waters, is confronted with a water resource problem. Agricultural agencies estimate the ultimate needs for supplemental irrigation in Maryland, when all irrigable land has been brought under supplemental irrigation, at 20.7 bil gal a year, which is only 0.8 per cent of the annual rate of replenishment. The estimated ultimate irrigation needs of the total tidewater region of Maryland is only twice that which the Bethlehem Steel Company obtains at one locality in tidewater Maryland. Obviously, adequacy of water resources is not a problem in supplemental irrigation. All other users together leave 94.3 per cent of the annual replenishment from which the supplemental irrigators can obtain the 0.8 per cent they will ultimately need.

The following remedial legislation has been recommended to cope with the water resources problem:

1. Amendment of the present water resources law to restore the exemption intended under that act in the words "domestic and farming" to read "domestic" only, and the definition of domestic use as that for household purposes, for watering farm livestock, and for the irrigation of home gardens and lawns. (Placing supplemental irrigation under the control of the present law will not result in denying anyone the use of the quantity of water needed for supplemental irrigation, but will serve to protect the ground water aquifers from salt water contamination by improperly placed wells.)

2. Modification of the doctrine of riparian rights by providing for allocation of water in excess of the average low flow of a stream to all lands in the drainage basin of the stream. (The effect will be to make available to all lands in a drainage basin those waters that exceed the needs of the riparian owners, and now run to waste. The pattern of the legislation to solve satisfactorily this legal problem is that (*1*) recommended in 1954 by the South Carolina Water Policy Committee. Such legislation will do no more than was contemplated in the original Maryland law, but will clarify a section whose scope is vague because of the failure to define "riparian rights.")

Pertinent to the question of riparian rights is this statement by C. E. Busby (*2*), of the US Dept. of Agriculture: "The landowner does not own the water in the stream—nor does anyone else. Many farmers do not understand that point. . . . Although a landowner may exhaust the stream to satisfy his natural domestic needs, users are limited to a so-called reasonable share for artificial needs, such as for irrigation. . . . What is a reasonable use of the common supply of one in relation to that of others? Our courts say that depends on all the circumstances surrounding the case. . . . Farmers are the ones that need the legislation most but understand their needs least."

3. Provide for financial aid in the construction of storage reservoirs for supplemental irrigation after the pat-

tern of financial aid for the construction of shore erosion protection works in Maryland. (Such an act would authorize county commissioners to borrow funds for the purpose and to amortize the bonds by annual assessments against the voluntary participants, upon their petition for such aid. Federal financial aid is already available to the extent of $25,000 for an individual and $250,000 to a group, through the US Dept. of Agriculture under the Water Facilities Act, with free expert advice as to economic practicability and with the preparation of plans and specifications through the local Farm and Home Administration office of the Dept. of Agriculture. The act provides further for federal insurance of loans made by lenders other than the United States. The main advantage of similar state legislation, under the administration of the state agricultural agencies, is the speeding of the processing of applications at local county level as against the tedious time-consuming machinery at the remote federal level.)

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Delaware—*John J. Groot*

A paper presented on Oct. 25, 1956, at the Chesapeake Section Meeting, Baltimore, Md., by John J. Groot, State Geologist, Delaware Geological Survey, University of Delaware, Newark, Del.

During the last few years it has appeared that many in Delaware fear that the state's water resources are being depleted at an ever-increasing rate. As water is indispensible to Delaware's economic well-being, a shortage would be a most serious disaster indeed. But is this anxiety warranted in view of the facts now known?

Resources

In 1954 the Delaware Geological Survey published a report on the geology and ground water resources of the state. It was found that the quantity of ground water available was about 16 times greater than ground water use in 1954. And, although, since the year 1954, ground water use has increased, there still exists today a comfortable margin of potential supply over use, and there is no doubt that this will be so for many years to come.

Within a few months there will be published an up-to-date report on the surface and ground water resources of northern Delaware (the area north of the Chesapeake and Delaware Canal). It has been found that, with relatively little effort and investment, twice the quantity of water can be developed that now is. As a matter of fact, much more water is running to waste to the ocean than could possibly be used now. Only a small percentage of the runoff of streams is being used, and, in most places, ground water reservoirs are still full and overflowing. Even if only 50

per cent of the mean flow of the main streams were utilized, four times the amount of water used at present could be developed. To do this will necessitate the building of several storage reservoirs at a considerable investment. Technically, however, it can be done.

Precautions

This does not mean that there is reason for complacency, because:

1. Optimum ground water development can proceed only on the basis of a thorough understanding of the hydrologic properties of the major water-bearing sands. It is necessary to know the safe yield of these aquifers, and the most suitable methods of well construction and well spacing. Most of so-called water shortages in Delaware are local ones which arise as a result of too great pumpage in too small an area. In order to achieve optimum development some legislation may be needed.

2. Ground water development should be carried on in such a manner that no salt water encroachment takes place.

3. The development of surface water resources necessitates the building of dams and reservoirs; this is not only a technical problem but also a financial one. Because interstate cooperation may be needed—particularly with Pennsylvania—political problems are also involved. Considering the time needed for developing surface water supplies, possible reservoir sites should be studied and acquired now.

Although it may not be necessary for Delaware to use the water of the Delaware River for water supply purposes other than cooling, it would seem provident for the state to "stake a claim" to the water in the Delaware River basin. It is not known what the water requirements will be in the more distant future, but it is possible that the desalting of brackish water will become a practical possibility; in such an event the process will probably be most economical when salinities are kept to a minimum. Some progress is being made in this respect, because, when additional water is taken from the basin by New York City, downstream releases of water are provided during drought periods. Such releases have the effect of limiting the upstream movement of the brackish water and are, therefore, of some benefit to Delaware.

Problems

Delaware's water resources problems, as can be observed on the basis of the established facts, are:

1. Problems of legislation enabling Delaware to allocate its resources wisely to prevent local shortages due to overdevelopment, while in other areas ground water reservoirs are full and overflowing

2. Problems of interstate cooperation, because it will be necessary to develop water primarily from interstate streams

3. Problems related to the economics of water supply. (How much can be safely spent on water resources development?)

4. Problems of distribution.

Briefly, the problem is to develop adequate water supplies in Delaware in the most economical manner and with due regard to sound conservation practices.

Iowa—*Wendell Pendleton*

A paper presented on Oct. 25, 1956, at the Iowa Section Meeting, Des Moines, Iowa, by Wendell Pendleton, Chairman, Iowa Study Committee on Water Rights and Drainage Laws, Storm Lake, Iowa.

The problem of water supply has become a matter of major concern to states and cities across the land. In California, state engineers have unwrapped a plan for correcting the monumental error of Mother Nature in laying out California's rivers. It seems that the fickle lady put too much water in the northern third of the state and too little in the central and southern sections. The importance of water can be appreciated when one considers the magnitude of California's contemplated expenditure—13 billion dollars. This is probably 75 times more than Iowa's annual budget (excluding highway allocations. Considering this, any modest expenditure on water use and conservation in Iowa, is certainly justified by the state's responsibility.

Committee Report

On Dec. 1, 1956, the Iowa Water Rights and Drainage Laws Study Committee, created by joint resolution of the general assembly, submitted its report to the Governor. The preliminary work of this committee has been in the nature of public hearings and public relations work aimed at alerting the public to the significance of the water problem. The committee, working with limited appropriations, has no salaried employees except for a part-time stenographer who has been helpful in getting out notices of meetings to the press, radio, television, legislators, county boards of supervisors, city and town governments, the farm bureau, and other interested persons and agencies. In addition, court reporters were employed to record the testimony at the hearings. Some of the findings of the committee follow in brief summary.

Present Law

The present water law in Iowa is both indefinite and inadequate. There are very few statutes regulating water use and the law is based on the common-law doctrine of riparian rights, subject to some authority delegated by statute to the conservation commission and the natural resources council. The statutory authority delegated to the conservation commission is essentially restricted to control over public recreational bodies of water. The statutory authority delegated to the natural resources council is broader, but probably the most significant power possessed by this agency is control over dams in rivers and streams. The doctrine of riparian rights states, in effect, that any owner of land which is contiguous to a watercourse has the right to make a reasonable use of that water but cannot alter the form of the water to the damage of anyone downstream from him. The doctrine has cast grave doubts on the rights of any individual to use water for irrigation, which would diminish the quantity of the water. It has also raised many perplexing problems in connection with municipal and industrial use of water. Most municipalities return a quantity of water comparable to that taken from the watercourse to

a stream or river in the form of effluent from their sewage treatment plants. The public, however, is apprehensive about the rights of cities and towns to take an ever-increasing amount of water. Part of the problem is the vexing question of rights acquired by prior use and prescription, and practicing attorneys are finding it difficult to advise individuals on their rights in water.

Clearly, there is a need for definitions of property rights in water, and a need for standards for determining permissive uses of water. In consequence of this indefinite and inadequate state of the law, maximum beneficial use of water resources is not being accomplished to any appreciable extent.

Competitive Consumption

There is increasing competition for water, and municipalities which rely on rivers for public water supply have shown concern. The city of Ottumwa, relying on the Des Moines River for its municipal needs, requires up to 10 mgd. The river flow has been down to low flowage rates of 20 mgd. In this situation a small number of farmers irrigating up stream could endanger the municipal supply. This problem is significant when one stops to realize that putting 1 in. of water on 1 sq mile of land would require 17.5 mil gal. The city of Clarinda has for 36 years taken all of its public water supply from the west branch of the Nodaway River. City officials report that this is not a matter of choice but a matter of necessity. The minimum flow ever recorded in the Nodaway River was in August 1919, when the flow reached a low of 750 gpm. Clarinda is currently taking 800 gpm from the river. The present river flow after 2 years of dry weather is 4,500 gpm. Municipal officials in Clarinda expect to increase their capacity to 1,200 gpm, which would leave a surplus of 3,300 gpm. They believe that it would not be impossible for this margin of safety to disappear if as few as six farmers upstream began irrigating in earnest during a dry year. At the present time, two farmers above Clarinda are irrigating, each taking about 500 gpm. Only a small number of municipalities relies on rivers for water supply, but to those few a potential increase in irrigators is a matter of deep concern.

On the other hand, it is known from the interest shown at public hearings that many farmers are considering irrigation in the immediate future. Irrigation equipment sales representatives are pointing out the possibilities of high profits and record yields in irrigation. Many farm operators are holding off pending a clarification of their legal rights, but others are going right ahead. Irrigation equipment varies in cost but it is understood that irrigation equipment sufficient to do the job can be purchased for as little as $3,000. Most farmers hesitate to make this investment until they have reasonable assurance that they will not be prevented from making full use of it.

The Iowa State Vegetable Growers' Association, which has pioneered irrigation in Iowa, has come forward with a draft of a bill to set up the doctrine of prior appropriation in Iowa. This bill would be modeled after the laws of the seventeen Western states which do not border on the Mississippi River. The proposed draft of the bill provides in part: "Title to a water right in Iowa is based upon prior use for a beneficial purpose, as established in court, or by notarized and witnessed statements, filed with the county recorder."

Of course, the doctrine of prior appropriation is based on the maxim "First in time, first in right." It includes the basic concepts of priority (in time) of claiming the water right, and diligence in the diversion and application of the water to a beneficial use. This doctrine is not without its shortcomings.

In the last session of the California legislature, there were over 500 bills introduced which dealt with some phase of the water law or water rights. In Iowa, the number of farmers using crop irrigation increased from 76 to 139 from 1949 to 1954. In Nebraska there are over 1.5 million acres under irrigation. In Texas in 1939, 200,000 acres were under irrigation and in 1953, 3,300,000 acres. As a result of irrigation, ground water which had been 10 ft from the surface in 1953 near El Paso is now 55–65 ft from the surface. From the geologists viewpoint, this constitutes the mining of water and may pose a very serious threat in the foreseeable future.

Iowa is considered a semi-humid state. The rainfall average over 50 years is 34 in. in southeastern Iowa to 28 in. in northwestern Iowa. Rainfall in the period 1953–56 has been only ½–⅔ of normal. All of this has caused increased farmer interest in irrigation and has given considerable momentum to the movement. Many farmers are going ahead with irrigation plans, gambling on the present state of the law, and hoping that some downstream owner will not seek an injunction to restrain their operation. If a statute providing for prior appropriation is adopted, the farmer who has made the gamble may have superior rights to available water as an appropriator. The livestock feeder is only mildly concerned with his water supply in the streams and rivers; he is more concerned with the ground water supply as it affects his well.

A definite increase in competition for water can be expected among farmers, municipalities, and industry.

Iowa industry is water conscious but has not shown any particular concern. Of course, any competition for water would involve industry. As T. E. Davidson II, director of the Iowa Development Commission points out (*1*), 39 per cent of the manufacturers responding to a survey conducted at the direction of the Governor indicated that water supply was an essential factor in influencing plant site selection. The requirements of certain industries for water can be demonstrated by production figures. For instance, it takes 320,000 gal of water to produce 1 ton of aluminum; 200,000 gal to produce 1 ton of synthetic rubber; 65,000 gal to produce 1 ton of steel. To refine a barrel of oil, the requirement is eighteen barrels of water.

Cognizance must also be taken of the increase in population. As the location of industry in Iowa is encouraged, population will increase. In 1910 there were about 92 million people in the United States, of which 30 million lived on farms. Today, there are about 165 million people in the United States and only about 22 million live on farms. The population is increasing at the rate of 1.5 per cent per year. In other words, population in the United States is increasing at a yearly rate equal to the number of people living in the entire state of Iowa in 1956. Some experts predict a population of 220 million by 1975.

Individual consumption of water is increasing. Forty years ago, the aver-

age daily use of water was 90 gal; today, it is 150 gal. This overall picture means a greater demand for usable water. It is felt that industry should be more concerned with water supply than has been indicated to the committee. In connection with industrial use of water, it is good to report that the committee has not heard any serious complaint of pollution.

Data Needed

More basic information on water supply is needed. It is reported that data have already been compiled on a considerable number of stream and river flows but that the information is incomplete on the smaller streams and ditches. It is hoped to incorporate these data in the final report.

In many states in which there has been extensive irrigation by both surface and ground waters, irrigators have pumped out each year more water than has been getting back into the underground beds. This is a tremendous disservice to those states and to the country at large. Ultimately, the point will be reached where there is little possibility that the water level will build up so that it can be pumped. Extensive pumping of ground water must be related to the available supply. More information is needed on the exact status of Iowa underground water and on how much can be safely used.

Iowa has a fairly strong program for obtaining this information, but it should be accelerated. Legislative action will be necessary to provide funds and an administrative procedure, and the program will require pooling of all available data from the geological surveys (both state and federal), from well drillers, chemists, engineers, and many other sources. Some of this information can be obtained almost directly from the wells available. It has been suggested that in places such as south central and southwest Iowa, the drilling of additional wells for test purposes only will be necessary. These wells could be constructed in an inexpensive manner, and it is believed that more water supplies could be found than have been to date. Farmers might do some testing for irrigation purposes and pool their resources for that purpose. The state might also do some testing, and the Iowa Natural Resources Council, the state department of health, Iowa Geological Survey, and the conservation commission are all acquiring data which would be helpful. This committee will undoubtedly recommend to the legislature that an appropriation be made for the purpose of water exploration, and that appropriations to finance the acquisition of basic data be increased as soon as possible and expanded for the years ahead.

Minimum flow requirements for fish and wildlife are lacking in many streams and rivers. It is not necessary to elaborate on this finding. Examples of dry river, creek, and stream beds are common, and any program which the committee recommends must consider the necessity of maintaining minimum flows in rivers and streams. In connection with this problem, it has been found that, in areas where watershed developments have been carried out, natural springs and water seepage from the ground sources have established the flow of water. In areas of southeast Iowa which have been very dry, a water flow has been maintained in the streams. No other conclusion can be arrived at but the basic premise that good soil conservation is good water

conservation. The use of terraces, contouring, structures, ponds, and other features seems to be very helpful.

Watershed Development

The Honey Creek project, a pilot watershed of about 9,000 acres in Lucas County, has worked out very well. One in Mule Creek in Mills County of roughly 8,000 acres, with about 28 structures, is nearing completion. Public Law 566 has made possible small watershed development with cost participation by the federal government. The 1955 session of the Iowa Legislature implemented this law with a subdistrict law, which permits farmers in the small watershed areas to petition their local soil conservation district and organize a subdistrict, with authority to levy up to four mills per dollar of property value to raise funds to maintain the structures that are installed. The development of watershed projects should be encouraged in every possible way. In connection with minimum flow requirements, it has been found that many irrigators take considerable water from streams in the spring when flows are high and put it on the land. One irrigator reported that he put 8 in. of water on his land in the spring of 1955 and that it helped considerably. No harm would be done by this type of irrigation, and certainly it would be a reasonable use.

Iowa needs more farm ponds. Over 10,000 farm ponds exist in Iowa and more are being constructed each year. The trend has been toward larger ponds because the smaller ponds tend to dry out in the summer, especially in times of low rainfall. Ponds have been recommended and installed primarily as a source of water for livestock. The federal government will participate in construction of ponds on a cost-sharing basis up to 60 per cent. Certain areas of the state are much more suitable for ponds because of the type of soil. A pond may be built anywhere in the state of Iowa if the bottom is sealed by the use of bentonite seal. The farm pond provides a reservoir for storage of water and also helps to hold the water on the land. In connection with farm ponds, it is interesting to note that a number of municipalities are considering ponds or reservoirs as a source of municipal water supply, and a number of towns are presently using such sources. Local boosters from two municipalities have urged the committee to help with the promotion of artificial lakes. Ponds can become the means of preventing the runoff of surface water and, as such, become a significant factor in making the maximum beneficial use of rainfall.

Ground Water Recharge

There is a need for recharging underground acquifers. The Iowa Well Drillers Association and AWWA advocate consideration of the possibilities of recharging ground water. Experiments in this type of water conservation have been conducted in other states. Water conducted into the aquifer by drainage wells can be stored with almost no evaporation. Such a program must be controlled and must be conducted under the supervision of the board of health. The drainage wells must be constructed with casing and with provision for filtering out sediment. Such projects are considered to have some possible flood prevention features. There is a possibility of

drainage wells in connection with drainage districts.

Drainage and Flood Control

The possibility of combining drainage districts and watershed development should be considered. The main water hazards connected with farming are flooding and improper drainage. Many drainage districts have been set up in the last 50 years to help increase arable land, and these districts have been trouble spots in many instances. Nearly all the drainage districts terminate just before the land breaks sharply to steeper slopes, a distance of ½–2 miles before the water reaches a river and, as a rule, erosion and flooding follow in the lower quarter to third of the subwatersheds. In such situations water is not being controlled properly.

As a solution, the drainage law might be extended to secure adequate drainage water control. In other words, drainage should be accomplished on a watershed basis. In Iowa, the conservancy district law, passed in 1949 by the general assembly was drawn to make possible the watershed drainage approach, but it has been used by only one district in 7 years. This statute needs examination by competent legal talent, by technicians, and by practical farmers to ascertain what is needed to make it more widely acceptable. Certainly, the principle of combining the solution of drainage problems with flood control measures is a desirable one to follow. At present, suggestions from drainage attorneys throughout Iowa are being processed, and the cooperation of the soil conservation department has been solicited to help formulate recommendations on the conservancy district law.

Legislative Proposals

A water law which will impose regulations on certain uses of water in the state of Iowa has been recommended.

Ultimately, the purpose of the committee recommendations is the greatest beneficial use of water resources together with protection of the public interest in areas where competing uses are involved. The following declaration of policy is incorporated in the legislative proposal:

> It is hereby recognized that the protection of life and property from floods, the prevention of damage to lands therefrom, and the orderly development, wise use, protection, and conservation of the water resources of the state by the considered and proper use thereof, is of paramount importance to the welfare and prosperity of the people of the state, and, to realize these objectives, it is hereby declared to be the policy of the state to correlate and test the powers of the state in a single agency, the Iowa Natural Resources Council, with the duty and authority to establish and enforce an appropriate, comprehensive, statewide program for the control, utilization, and protection of the surface and ground water resources of the state.
>
> It is hereby declared that the general welfare of the people of the state of Iowa requires that the water resources of the state be put to beneficial use to the fullest extent of which they are capable and that the waste or unreasonable use, or unreasonable methods of use of water be prevented, and that the conservation be exercised with the view to the reasonable and beneficial use thereof in the interest of the people, and that the public and private funds for the promotion and expansion of the beneficial use of water resources shall be invested to the end that is served.
>
> Water occurring in any basin or any watercourse, or other natural body of water of the state, is hereby declared to be public waters and public wealth of the people of the state of Iowa, and subject to use in accordance with the provisions of this act, and the control and development and use of water for all beneficial purposes shall be in

the state, which, in the exercise of its police powers, shall take such measures as shall effectuate full utilization and protection of the water resources of the state of Iowa.

At present, law which deals with water use in Iowa was passed in 1949 and deals largely with flood control, although it does provide in general terms for the conservation, development, and use of water resources.

It is the considered opinion of the members of the Iowa Water Rights and Drainage Law Study Committee that the Iowa Natural Resources Council is the proper agency of government to administer the use of water in the state of Iowa. For this reason, the original 1949 law is used as the starting point and the basis for the recommended legislative enactment.

It is the judgment of the committee that the Iowa Natural Resources Council should more properly be designated as the "Iowa Water Resources Council" because the duties and responsibilities of the council at the present time are directly related to the control of water and the protection of the surface and underground water resources of the state.

The legislative proposal would include incorporation of statutory definitions of terms connected with water use. Certain uses would be regulated, and these would include water for irrigation of crops, water for air conditioning, and industrial use of water. The legislature will have to act upon any of the recommendations before they have any effect as law and it is the author's experience that the members of the legislature have distinct viewpoints of their own.

The following excerpts are taken from the proposed redraft of the 1949 law (Chapter 455, Code of Iowa 1954) which was submitted together with the committee report:

A.1 (Amended) Definitions. . . .

Flood plains means the area adjoining the river or stream which has or may be hereafter covered by flood water.

Floodway means the channel of a river or stream and those portions of the flood plains adjoining the channel, which are reasonably required to carry and discharge the flood water or flood flow of any river or stream.

Council floodway means a floodway designated and established by order of the council, fixing its length and landside limits.

Person means any natural person, firm, partnership, association, corporation, state of Iowa, any agency of the state, municipal corporation, political subdivision of the state of Iowa, legal entity, drainage district, levee district, public body, or other district or units maintained or to be constructed by assessments, or the petitioners of a proceeding pending in any court of the state affecting the subject matter of this chapter. . . .

Surface water means the water occurring on the surface of the ground.

Ground water means that water occurring beneath the surface of the ground.

Diffused waters means waters arising by precipitation and snow-melt, and not yet part of any watercourse or basin, and shall include capillary soil water.

Depleting use means the storage, diversion, conveyance, or use of any supply of water which impairs rights of lower or surrounding users.

Beneficial use means the application of water to a useful purpose that inures to the benefit of the water user and is subject to his dominion and control but does not include the waste or pollution of water.

Nonregulated use means the use of water for ordinary household purposes,

use of water for poultry and domestic animals, any beneficial use of surface flow water from rivers bordering the state of Iowa, existing beneficial uses of water within the territorial boundaries of municipal corporations on the effective date of this act, and any other beneficial use of water by any person of less than 5,000 gpd.

Regulated use means any depleting use except a use specifically designated as a nonregulated use. For the purpose of administering this act, any municipal corporation which increases the capacity of its water supply system to provide for increased use in excess of 100,000 gpd more than its highest per day beneficial use (or by 3 per cent of capacity—whichever is greater) prior to the effective date of this act, shall first secure a permit; and, any person using in excess of 5,000 gpd, diverted or withdrawn from any source of supply except a municipal water system or any other source specifically exempted under the provisions of this Act shall secure a permit; and, any person who diverts water or any material from the surface directly into any underground watercourse or basin shall first secure a permit.

Permit means the written authorization issued by the water commissioner or council to a permittee which shall be limited as to quantity, time, place, and rate of diversion or withdrawal in accordance with the declared policies and principles of beneficial use set forth in this chapter.

Permittee means the person who obtains a permit from the council authorizing such person to take possession by diversion or otherwise and to use and apply an allotted quantity of water for a designated beneficial use, and who makes actual use of the water for such purpose.

Waste means (a) permitting ground water or surface water to flow, taking it or using it in any manner so that it is not put to its full beneficial use; (b) transporting ground water from its source to its place of use in such a manner that there is an excessive loss in transit; (c) permitting or causing the pollution of a fresh-water strata through any act which will cause salt water, highly mineralized water, or otherwise contaminated water to enter it.

Watercourse means any lake, river, creek, ditch, or other body of fresh water or channel having definite banks and bed with visible evidence of the flow or occurrence of water, except such lakes or ponds without outlet to which only one landowner is riparian.

Basin means a specific subsurface water-bearing reservoir having reasonably ascertainable boundaries.

Established average minimum flow means, when reasonably required for the purpose of this act . . . the average minimum flow for a given watercourse at a given point thereon [as established by the council]. The "average minimum flow" for a given watercourse as used in this act shall be determined by the following factors: (a) average of minimum daily flows occurring during the preceding years chosen by the council as more nearly representative of changing conditions and needs of a given drainage area at a particular time; (b) minimum daily flows shown by experience to be the limit at which further withdrawals would be harmful to the public interest in any particular drainage area; and (c) those minimum daily flows shown by established discharge records and experiences to be definitely harmful to the public interest. Such determinations shall be based upon available flow data, supplemented, when available data is incomplete, by whatever evidence is available. . .

.3 Creation. There is hereby created and established an Iowa natural resources council. The council is established as an agency of the state government to promote the policies set forth in this chapter and shall represent the state of Iowa in all matters within the scope of this chapter. . .

.9 Director. The council shall choose a director who shall not be a member of

the council and shall fix the compensation of such director, which shall be payable out of the funds appropriated to the council. The director shall be qualified by training and experience. The term of office of the director shall be during the pleasure of the council. The director shall serve as the executive officer of the council and shall have charge of the work of the council subject to its orders and directions.

.9(1) (New Section) Water Commissioner. The council shall choose a water commissioner who shall not be a member of the council or a member of the staff and shall fix the compensation of such commissioner, which shall be payable out of the funds appropriated to the council. The water commissioner shall be qualified by training and experience. The term of office of the water commissioner shall be during the pleasure of the council. The water commissioner shall serve in a quasi-judicial capacity as the trier of fact questions in the processing of all applications for appropriation permits. He shall conduct hearings on any applications for permits as provided by law and the rules and regulations of the council, and he shall perform such other duties as the council may prescribe. . .

.18 (Amended) Jurisdiction—diversion of water.

(1) The council shall have jurisdiction over the public and private waters in the state and the lands adjacent thereto necessary for the purposes of carrying out the provisions of this chapter. The council shall make a comprehensive study and investigation of all pertinent conditions of the areas in the state affected by floods; determine the best method and manner of establishing flood control; adopt and establish a comprehensive plan for flood control for all the areas of the state subject to floods; and determine the best and most practical method and manner of establishing and constructing the necessary flood control works. The council may construct flood control works or any part thereof. The council is authorized to perform such duties in cooperation with other states or any agency thereof, or with the United States or any agency of the United States, or with any person as defined in this chapter. . .

(4) Upon application by any person for permission to divert, pump, or otherwise take waters from any watercourse, underground basin or watercourse, drainage ditch or settling basin within the state of Iowa for any purpose other than a nonregulated use, the council shall cause to be made an investigation of the effect of such use upon the natural flow of such watercourse and also the effect of any such use upon the owners of any land which might be affected by such use, and shall hold a hearing thereon. . .

(11) No person shall take water from any natural watercourse, underground basin or watercourse, drainage ditch, or settling basin within the state of Iowa for any purpose other than a nonregulated use except upon compliance with the provisions of this act. . .

(14) The right of the permittee and his successors to the use of water shall terminate when he ceases for three consecutive years to use it for the specific beneficial purpose authorized in his permit; provided, however, that upon his written application prior to the expiration of said 3-year period for extension of said permit, the council may grant such extension without loss of priority.

(15) A permittee may sell, transfer, or assign his permit by conveying, leasing, or otherwise transferring the ownership of the land described in the permit; but such permit shall not constitute ownership or absolute rights of use of such waters, but such waters shall remain subject to the principle of beneficial use and the orders of the council.

(16) The state of Iowa, any subdivision thereof, municipal corporation, or the state conservation commission, for the purpose of carrying out any permission

granted, as hereinbefore provided, shall have and exercise the power of eminent domain.

Some changes in present statutes are needed to permit better control of water use and to promote better conservation of water resources. A continuation of a study group to search for the solution of problems in connection with water is recommended.

EDITOR'S NOTE: The legislative proposal discussed above was passed unanimously by the Iowa General Assembly and was signed into law by the governor on May 2, 1957.

Correction

The article "Ground Water in the South Carolina Coastal Plain," by George E. Siple (March 1957 JOURNAL, Vol. 49, pp. 283–300) had an omission in the first sentence, second paragraph, on p. 299, col. 2. The sentence should read: "The principal aquifers, in point of potential yield and present use, are those in the Tuscaloosa, Black Creek, and Peedee formations *of late Cretaceous age, and the Santee limestone and McBean formations* of early Tertiary age."

Radioactive Tracers in Sanitary Engineering

Conrad P. Straub and G. Richard Hagee

A paper presented on Mar. 11, 1957, under the joint sponsorship of AWWA and ASCE, at the Engineers Joint Council's Nuclear Eng. and Science Congress, Philadelphia, Pa., by Conrad P. Straub, Chief, Radiological Health Program, and G. Richard Hagee, In charge, Instrumental and Physical Methods, both of the Robert A. Taft San. Eng. Center, USPHS, Cincinnati, Ohio.

IN the sanitary engineering field, as in other branches of engineering and science, increasing use is being made of radioactive materials as tracers. Of most importance to the profession have been the studies utilizing these new tools for the measurement of longitudinal mixing in pipes (*1, 2*); for determination of flow time and dispersion in watercourses (*3–5*), artificial basins (*7–11*), and ground water; for tracing distribution of pollution from ocean outfalls; for evaluation of the removal of bomb debris from the atmosphere by the environment and by water treatment plants (*12–13*); and for rapid detection of coliform organisms (*14*). The following are descriptions of several studies carried out at the Robert A. Taft Sanitary Engineering Center in Cincinnati.

Stream Flow Studies

The time of flow of the Ottawa River below Lima, Ohio, was determined by chemical (sodium chloride), colorimetric (fluorescein dye), and radioactive tracer (rubidium 86) techniques. This information was needed for estimation of the time required for organic material, discharged with the effluents from an activated sludge sewage treatment plant and an industrial plant, to reach specific locations downstream. To obtain these data under low stream flow conditions, two runs were made during a 2-week period in August 1956.

For the first run, 1.5 lb of fluorescein dye and 265 millicuries (mc) of rubidium 86 tracer were added to the Ottawa River at the sewage treatment plant outfall. At the midpoint and quarter points of the stream 1-qt samples were collected at each of two downstream stations, located 1.0 and 1.9 miles below the point of introduction of the tracers. Duplicate 100-ml portions were taken for laboratory counting and for determination of fluorescein concentration. The temperature of the residual sample was recorded and the activity level was measured on a survey meter and a field scaler unit,* each of which was equipped with a rubber-encased Geiger-Muller probe. A notation was also made as to whether the dye concentration was higher or lower than that of the preceding samples.

In the laboratory, a minimum sample of 10 ml was placed in an aluminum dish, evaporated to dryness, and counted in an internal proportional counter.† Following necessary corrections, the results were plotted as indi-

* The survey meter (Model MX5), and the field scaler (Model 80), are both products of Beckman Instrument Co., Richmond, California.

† The proportional counter used was a Model PC-1, manufactured by Nuclear Measurements Corp., Indianapolis, Indiana.

cated in Fig. 1 and summarized in Table 1. The results show that for a flow volume of approximately 23–26 cfs the modal time of flow was 4.0 hr from the sewage treatment plant outfall to Station A and 10.4 hr to Station B when the laboratory counting data were used, and 4.1 hr and 10.6 hr, respectively, when the field counting data were used. No satisfactory data ord of the activity levels (integrated) passing Station A. Unfortunately, the unit failed just at the time that activity reached this station. Samples were collected as in the first run, but no field measurements were made and all samples were measured in the laboratory. Because of the increased concentration of dye added, it was possible to follow the dye for a greater distance, and sam-

TABLE 1

*Data on Midstream Flow Time of Ottawa River, Lima, Ohio**

		Time Elapsed When Maximum Concentration (Mode) Was Reached					
	Tracer	Point of Introduction to Station A	Point of Introduction to Station B	Station A to Station B	Point of Introduction to Station C	Station B to Station C	Station A to Station C
Run 1	Rb^{86}†	3 hr 57 min	10 hr 27 min	6 hr 30 min			
	Rb^{86}‡	4 hr 8 min	10 hr 38 min	6 hr 30 min			
Run 2	Rb^{86}†	4 hr 10 min	10 hr 15 min	6 hr 5 min	21 hr 30 min	11 hr 15 min	17 hr 20 min
	Fluorescein Dye	4 hr	10 hr	6 hr	21 hr 30 min	11 hr 30 min	17 hr 30 min
	NaCl§	5 hr 30 min	11 hr	5 hr 30 min	22 hr	11 hr	16 hr 30 min

* The same data are plotted in Fig. 1.
† Proportional counter data.
‡ Field scaler data.
§ Introduced approximately 0.1 mile upstream of fluorescein dye and Rb^{86}.

were obtained with the survey meter or with the dye.

In the second run made a week later, the amount of fluorescein used was increased to 6 lb because of the erratic results obtained in the initial run. The dye, with 300 mc of rubidium 86, was added at the sewage treatment plant outfall. In addition, 3,000 lb of sodium chloride was released at a point approximately 0.1 mile upstream. The flow in the stream was approximately 19–21 cfs. Since the field scaler readings showed some promise, this unit was selected to give a continuous rec- ples were collected at a third station—Station C—located 4.5 miles below the sewage treatment plant outfall.

The results of the second run are plotted in Fig. 2 and summarized in Table 1. It will be seen that the times of flow between the various stations, as determined by either of the three tracer techniques, were similar.

Pilot Plant Flow Studies

The detention time of two units of an anaerobic sewage treatment pilot plant located at Loveland, Ohio, was determined on Sep. 5–10 and Dec. 12–13,

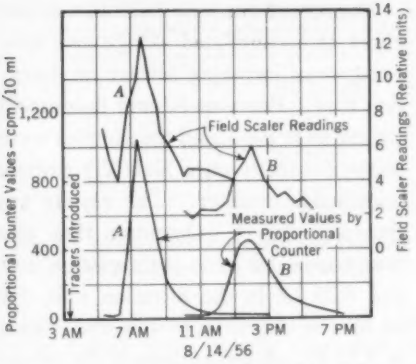

Fig. 1. Results of Flow Study Using Radioactive Tracers

Study was made in the Ottawa River below Lima, Ohio. Curves A *and* B *are for samples collected at test stations so designated. Proportional counter measurements are taken in the laboratory.*

1956. A theoretical detention time of 17.3 hr was provided in the upflow filter unit for a total designed detention time of 22.8 hr.

In the early run, 6 mc of rubidium 86 was introduced together with fluorescein dye a short distance before the inlet of the digestion unit. Samples collected at the discharge side of the digestion unit and at the discharge side of the filter unit were evaporated to dryness and counted with an end-window Geiger-Muller counter.* The results of the study are shown in Fig. 3. As can be seen, the first traces of rubidium and dye were noted shortly after the addition of the tracer. In fact, the peak activity in the primary

* Model TGC-2, a product of Tracerlab Inc., Boston, Massachusetts.

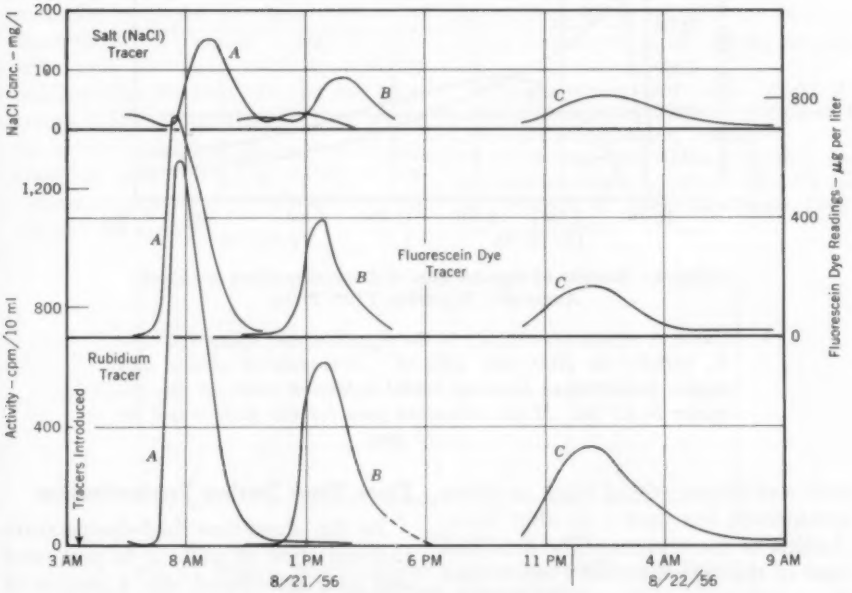

Fig. 2. Results of Second Run of Flow Study Showing Data for Radioactive and Other Tracers

Curves A, B, *and* C *are for samples collected at test stations so designated. No field measurements were made in this part of the study.*

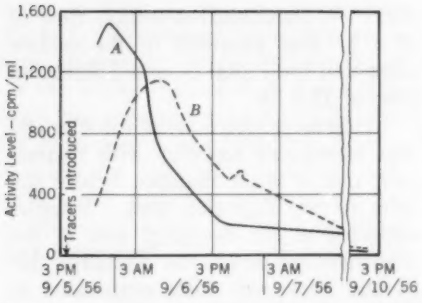

Fig. 3. Results of Detention Time Study Made With Radioactive Tracers of Anaerobic Digestion Pilot Plant at Loveland, Ohio

Curve A *represents activity in the digestion unit effluent, Curve* B, *activity in filter unit effluent. Modal detention time for the digester was 7 hr 45 min, for the filter, 8 hr.*

The second run was made to note the effect of accumulated sludge and temperature of incoming sewage on detention time. Bromine 82 and fluorescein tracers were used, and the samples were counted directly on a NaI(Tl) gamma scintillation counter. The results are shown in Fig. 4. Detention time was found to be 1.5 hr in the digestion unit and 8.25 hr in the filtration unit, for an overall detention time in the system of 9.75 hr. A comparison of the detention time prevailing in the digestion unit at this time with that obtained earlier indicates the effect of accumulated sludge and of temperature-induced short-circuiting.

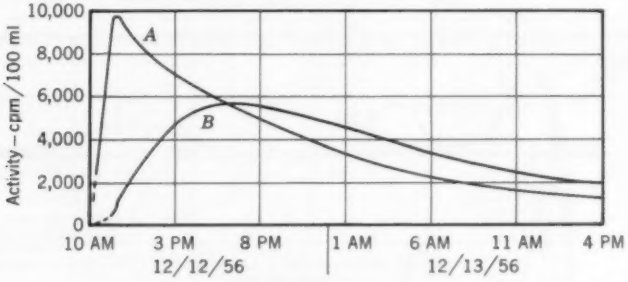

Fig. 4. Results of Second Run of Detention Time Study of Anaerobic Digestion Pilot Plant

Curve A *represents activity in the digestion unit effluent, Curve* B, *activity in filter unit effluent. Accumulated sludge and higher temperature lowered modal detention time for the digester to 1.5 hr. Modal detention time for the filter was 8 hr 15 min.*

unit was almost missed when sampling commenced less than 6 hr after introduction of the tracers. The detention time of the digestion unit (based upon the maximum activity level or modal value) approximated 7.75 hr, and of the filter unit, 8 hr, for a total detention time in the system of 15.75 hr.

Flow Time During Pasteurization

In the short-time high-temperature pasteurization of milk, it is preheated and then introduced into a section of pipe kept at the necessary elevated temperature, where it remains for sufficient time to insure pasteurization. Since the flow of preheated milk is not uni-

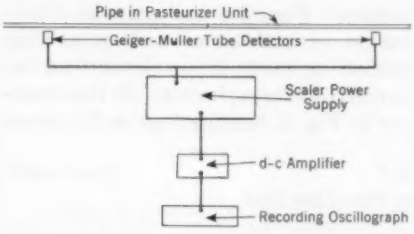

Fig. 5. Instrument Assembly for Pasteurization Holding-Time Measurements

form (the liquid in the center of the pipe moves more rapidly than that at the circumference), the time of first appearance of the preheated milk at the initial and final correct temperature points in the system is needed.

The conventional method of determining flow time in pasteurization is by conductivity measurements. However, since milk itself is an electrolyte, measurement must be made indirectly. Accordingly, a material foreign to both milk and water is used in making holding-time studies. In the use of a tracer, it is assumed that the time interval between the first appearance of the tracer at each measuring station of the system represents the minimum holding time of the system.

With a gamma-emitting radioisotope such as Iodine 131, a suitable detector attached to the outside of the pipe may be used to measure the activity levels at the two points of reference. The activity levels must be related to a sensitive timing device, because the time of passage is of extreme importance. The method of determining holding time was developed for use in the laboratory with water as the flowing medium; it cannot be employed in an actual installation processing milk for human consumption.

As shown in Fig. 5, the apparatus consisted of two Geiger-Muller tube detectors, a high-voltage power supply scaler assembly,* and a d-c amplifier feeding into a recording oscillograph.† Although used to record pulses rather than current output from a ratemeter, the oscillograph provided some estimate of the concentration of activity at each

* The instrument used was a Model 161 scaler, a product of Nuclear Instrument & Chemical Corp., Chicago, Illinois.

† The d-c amplifier (Model BL-202) and recording oscillograph (Model BL-932) are both products of Brush Electronics Corp., Cleveland, Ohio.

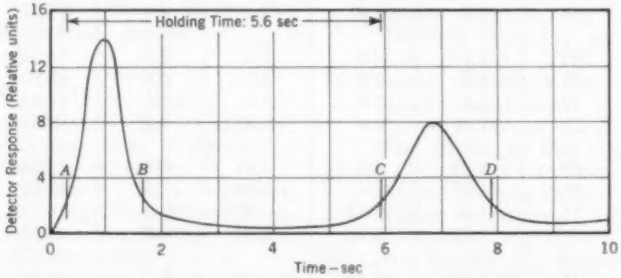

Fig. 6. Typical Distribution of Activity on Oscillograph Record of Holding-Time Measurements

Points A–B *and* C–D *indicate limits of appearance of activity, the holding time being computed as the distance (time) from one initial appearance of activity* (A) *to the next* (C).

measuring station by the density of pen strokes on the strip chart. Measurements were made at 2-ft increments along the pipe and ranged from 31 to 247 in.

creases. Figure 6 indicates the distribution of activity at each measuring station as taken from transcribed recorded oscillograph data. In the example in Fig. 6, holding time is 5.6 sec as

TABLE 2

Summary of Pasteurizer Flow Time Data

Experiment No.	Distance Between Stations (D) *in.*	Duration of Activity, or Time to Traverse Distance		Holding Time (T) *sec*	Quantity of I^{131} Used *mc/10 ml*	$\frac{D}{T}$ *in./sec*	Chart Speed *mm/sec*
		A–B sec	*C–D sec*				
1	247	1.8	5.0	17.6	0.5	14.03	5
2	247	2.4	6.4	17.9	1.0	13.80	5
3	247	1.5	5.0	17.5	1.25	14.11	5
4	247	1.4	2+	18.1	0.05	13.65	5
5	247	1.4	4.4	17.6	0.5	14.03	5
6	247	1.6	4.4	17.6	0.5	14.03	5
7	247	1.4	4.8	17.8	0.5	13.88	5
8	247	1.6	4.6	17.8	0.5	13.88	5
9	247	1.6	4.6	17.8	0.5	13.88	5
10	223	1.4	5.0	16.0	0.5	13.94	5
11	223	1.4	3.6	16.0	0.5	13.94	5
12	199	1.6	3.2	14.2	0.5	14.01	5
13	199	1.6	4.0	14.0	0.5	14.21	5
14	175	1.4	3.6	12.4	0.5	14.11	5
15	175	1.4	3.6	12.2	0.5	14.34	5
16	151	1.4	3.1	10.7	0.5	14.11	5
17	127	1.4	3.2	9.0	0.5	14.11	5
18	127	1.3	3.3	8.8	0.5	14.43	5
19	127	1.5	3.0	9.0	0.5	14.11	5
20	103	1.5	2.8	7.2	0.5	14.31	5
21	103	1.4	3.0	7.2	0.5	14.31	5
22	79	1.8	2.5	5.7	0.5	13.86	5
23	79	1.6	2.8	5.4	0.5	14.63	5
24	79	1.24	2.4	5.32	0.5	14.85	25
25	79	1.22	2.1	5.44	0.5	14.52	25
26	55	1.32	2.6	3.64	0.5	15.11	25
27	55	1.48	2.52	3.80	0.5	14.50	25
28	31	1.44	1.92	2.16	0.5	14.35	25
29	31	1.48	2.24	2.14	0.5	14.49	25

The results of an extended series of tests are summarized in Table 2 and show that the holding time increases as the distance between stations in-

determined from the times of initial appearance of activity, as contrasted with a value of 5.85 sec based on the maximum (or modal) values.

The studies are being continued to determine the effect of initial temperature on the flow time through the system, and will be extended to use milk as the flowing medium.

Summary

Studies are described in which radioactive tracers were used singly or in combination with either dye or chemical tracers to define the flow time in streams, pilot plant facilities, and pasteurization equipment. Where multiple tracers were employed, similar flow times were found. The isotopes used were rubidium 86, bromine 82, and iodine 131. Various types of instrumentation were also employed, including proportional counters, Geiger-Muller end-window counters, field scalers, survey meters, and a gamma scintillation counter.

Acknowledgments

The authors express their appreciation to F. J. Ludzack for permission to use the Ottawa River fluorescein and dye data, to J. E. Campbell and R. C. Thomas for the pasteurization holding-time data, and to A. S. Goldin, G. Karches, and R. N. Bloomhuff for their assistance in the Ottawa River and Loveland Pilot Plant studies.

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Stream Surveys for Radioactive Waste Control

Ernest C. Tsivoglou, Ernest D. Harward, and W. Marcus Ingram

A paper presented on Mar. 11, 1957, under the joint sponsorship of AWWA and ASCE at the Engineers Joint Council's Nuclear Eng. and Science Congress, Philadelphia, Pa., by Ernest C. Tsivoglou, San. Engr., Ernest D. Harward, San. Engr., and W. Marcus Ingram, Biologist, all of the US Public Health Service. Tsivoglou and Ingram are at the Robert A. Taft San. Eng. Center, Cincinnati, Ohio, and Harward is at the Pittsburgh Area Office, US Atomic Energy Com.

THE rapidly developing private use of radioactive materials emphasizes the importance of stream surveys for the adequate control of radioactive liquid waste discharges from nuclear reactors, uranium mills, radioisotopes research laboratories, and other sources of contamination. Concern in this matter results, of course, because excessive radioactive waste discharges will interfere with other legitimate uses of a stream. Domestic water supplies, for example, must not become contaminated beyond levels which are considered safe. Other stream uses which may be impaired or prevented by radioactive effluents include: irrigation of croplands, stock watering, commercial and sports fishing, industrial process water supply, and recreation. Modern water resources philosophy stresses the development of multiple stream uses, and opposes the use of a stream for a single purpose, such as for waste disposal, to the exclusion of other desirable uses.

Nature of Task

The water pollution problems associated with the atomic energy industry are similar to those encountered with other industries, except for the nature of the pollutant and details such as measurement techniques. It is anticipated, therefore, that control of radioactive wastes from this industry will be administered by existing regulatory agencies, according to the same general methods and policies practiced for other more familiar industrial effluents (*1, 2*). Stream surveys for radioactive waste control, and the interpretation of the data collected, differ somewhat from those for more ordinary water pollutants because of the peculiar character of radioactive wastes and the manner in which they affect the stream. One reason for this is that there exists no stream self-purification capacity for radioactive wastes in the sense that a stream purifies itself of ordinary organic pollutants.

As is known, organic pollutants undergo biochemical oxidation resulting from bacterial attack in a stream, so that the stream rids itself of the pollutants generally within a few days after they are discharged. In this sense, the stream has a self-purification capacity for organic wastes. No similar process occurs for radioactive materials in the stream environment. In flowing downstream, the concentration of a specific radioisotope will be reduced by dilution with additional uncontaminated tributary flow and by

natural radioactive decay according to a fixed and immutable half-life for that particular radioisotope. Dilution, of course, reduces the water concentration but not the total amount of radioactive material present. Both the concentration and quantity of material present may *appear* to have been reduced as the result of sedimentation of suspended solids and uptake by aquatic organisms. Neither of these actions, however, reduces the total amount of radioisotope present in the stream environment; the material is simply transferred to other phases of the environment, namely, bottom deposits or biological cell content. Stream self-purification in the accepted sense does not occur, and radioactive decay according to fixed half-life is the only means by which the total amount of radioactivity in the stream environment is diminished.

A great deal is still unknown regarding the human uptake of radioactive elements and their direct and indirect physiological effects once ingested. The long-term effects of chronic exposure to radioactive materials in low concentration are still largely unknown. Only scattered bits of knowledge regarding the extent and significance of uptake of radioelements by the aquatic biota exist. For these reasons, and because of the stream's inability to purify itself of radioactive contamination, the only recourse in the problem of safe disposal of radioactive liquid wastes is to proceed with caution. Maximum concentrations of radioisotopes which are presently considered safe for domestic water supply have been suggested (*3*). As more is learned regarding the effects of chronic radiation exposure and the effects of radioactivity upon other stream uses, it is anticipated that some of the concentrations presently accepted as safe will be revised, either upward or downward. The maximum permissible concentrations of specific radioisotopes in water, as given in handbooks of the National Bureau of Standards (*3, 4*), are not viewed as concentrations to be met or exceeded. They are the upper limits which are thought to be tolerable, and the National Committee on Radiation Protection has urged that actual concentrations be kept as far below these values as is economically and reasonably possible (*3*).

With radioactive materials, just as with more ordinary pollutants, the stream survey is the key means of quantitatively defining the problem and determining the extent and effects of contamination. It is the basis of control of radioactive water pollutants.

Organization and Planning

Just as with other pollutants, the planning and performance of stream surveys for radioactive contamination depend upon the specific survey objectives. The primary purposes for stream radioactivity surveys might include, for example: obtaining radioactivity background data for streams of a river basin or streams near the site of an anticipated industry; controlling radioactive waste discharges from an existing nuclear plant; or simply, obtaining data for the record. Reconnaissance surveys may be performed for preliminary evaluation of an existing situation, or stream radioactivity surveys may be carried out mainly for purposes of research and the development of new information. Depending upon which of the foregoing aims is paramount, the location of stream sampling points, frequency of sample collection, types of sample, types of laboratory analysis, and other factors will differ considerably.

Equipment and Personnel

Performance of any stream survey is predicated on the assumption that adequate laboratory facilities and personnel with the necessary competence are available. Some discussion of equipment and personnel needs is therefore pertinent before going into survey details.

Depending upon the size of the radiological program, its purposes, and the kind of work to be performed, there are wide varieties of laboratory requirements, including those of space and equipment. Also to be considered in this regard are: the sample load expected; whether the samples will involve low or high activities, or both; whether analyses will be solely for gross radioactivity as against identification and measurement of specific radioelement concentrations; and, of course, available funds and personnel. On the basis of these and other factors, the laboratory facility may range from a corner in a general state water pollution laboratory to a major separate radiological laboratory full equipped for all eventualities.

The minimum laboratory facility for water monitoring need not be expensive and will occupy only a small amount of space. The facility is suitable, for example, as the initial installation for a state water pollution control agency, and its equivalent is presently in use in several such laboratories. Its essentials are: an internal proportional counter; two or three standard radioactivity sources for instrument calibration and checks; planchets in which samples are evaporated and counted; and, perhaps, membrane filter papers for separate counting of suspended radioactive material. Samples are evaporated under an effective exhaust hood, usually available and not an extra expense. Such a minimum facility is capable of much of the regulatory work that will be necessary in the near future. It can handle approximately 100 samples per month, or more for gross alpha and gross beta radioactivity determination. With ordinary laboratory glassware and other equipment usually at hand, water, biological, and river mud samples can be analyzed. The only additional space requirements are for the counting instrument and intermittent use of the exhaust hood. It has been estimated that this equipment can be obtained for approximately $1,500 (*1*).

The foregoing minimum facility has its drawbacks, of course. Foremost among them is the complete dependence upon a single counting instrument, which may break down or become accidentally contaminated with radioactive material, requiring rather extensive decontamination. Either of these eventualities can deprive the laboratory of its instrument for some time. It is also desirable, if possible, to perform alpha and beta counting in separate, designated instruments. Accordingly, as soon as possible, a second internal proportional counting instrument should be added. After this, whenever feasible, an end-window Geiger-Muller tube counter, adequately shielded with lead to reduce the background count rate, is useful for beta and gamma counting and more rapid handling of samples, and should be obtained, together with a set of absorbers for differentiating the types of radioactivity present in a sample and providing rough estimates of the energy distribution.

Training

Short-term training courses, such as are available at the Robert A. Taft Sanitary Engineering Center of the US Public Health Service, are adequate to

prepare water pollution laboratory personnel for the necessary sample preparation and gross counting of stream samples. These courses last 5 weeks, and can be attended separately for periods of 1 or 2 weeks. Only limited training can be given in such a brief time, and in terms of expected future needs, more extensive training of key laboratory personnel at colleges or universities is desirable.

Larger Programs

While the foregoing laboratory and personnel requirements suffice at present for a minimum water pollution radiological program, it seems clear that adequate water pollution control will eventually require, in some instances, identification and measurement of specific radioelements. At points downstream from nuclear reactors it may prove desirable to identify and measure radiostrontium, radioiodine, and other specific radioisotopes (*5*). Downstream from the reactors at Hanford, Wash., the specific determination of radiophosphorus has been important (*6*). For streams below uranium mills, analysis for radium may be necessary (*7*). Such procedures may be more or less complex, depending upon the element involved, and may require special laboratory equipment and more highly trained radiochemists and physicists.

The laboratory facility at the Robert A. Taft Sanitary Engineering Center is an example of a more extensive program. There is an entirely separate air-conditioned counting room housing eight counters. Constant voltage transformers assure a steady power supply to these instruments. There is a separate radiochemistry laboratory in which no other work is performed; this laboratory has an exhaust hood system entirely independent of the ducts in the rest of the building, so that the spread of radioactive contamination throughout the building is prevented. Also available is a pulse height analyzer for identification of radioisotopes by measurements of the energy of emitted radiations. The staff for this program includes sanitary engineers, a radiochemist, a physicist, and several laboratory technicians. Research is carried on to develop new or improved analytical methods for specific radioisotopes, and the group provides technical assistance to other programs at the center as, for example, in the use of radiotracers in research.

In an operation such as that connected with the power reactor being constructed at Shippingport, Pa., it is highly desirable to have physically separated laboratories for low-level and high-level radioactivity work, in order to avoid contaminating equipment used for low-activity (background) samples. Field trailer laboratories, fully equipped, have been used by the US Public Health Service (*6*), and in smaller scale studies, samples have been shipped to the central laboratory for analysis (*7, 8*). When wastes include radioisotopes having a short half-life, the delay between sample collection and analysis after shipment to a central laboratory can necessitate the use of field trailer facilities or a temporary laboratory setup in a local building.

Depending, then, upon the purpose and the anticipated sample load, analyses, and other factors, the stream radiological laboratory and personnel needs vary widely. For state water pollution control agencies, for instance, a minimum laboratory will usually suffice for the present, and will permit the necessary determination of background radioactivity levels and the small

amount of routine waste control work presently required.

Stream Water Samples

Problems of water pollution control involving familiar organic and industrial wastes, customarily deal almost exclusively with water samples from streams. With radioactive pollutants, however, water samples alone cannot provide adequate information, and it is necessary to work also with samples of the stream biota and bottom deposits in order to obtain an integrated picture of the effects of these wastes. Investigators are fortunate, in a sense, because radioactive materials are excellent trace elements—it is quite possible to track them accurately over relatively long stretches of rivers and river systems by rational sampling, and, if necessary, to identify them exactly.

Samples of river water are one index of the degree of radioactive contamination of a stream and its effects in terms of water use. This type of sample can yield data as to the gross radioactivity content of the flowing water, in both dissolved and suspended form, and, if desired, water samples can be analyzed for specific radioelements such as radium or strontium. The interpretation and significance of results thus obtained is dependent upon how representative a sample has been collected.

Grab samples of river water provide an instantaneous measurement of water quality, and nothing more. As an indication of radioactivity background concentrations at stream locations upstream of all industrial sources, they are quite useful. They can also be an adequate measure of stream water quality at locations below an anticipated industrial waste source. Grab samples may be collected by any of the time-honored methods which are most appropriate. For small streams, wading and direct filling of a polyethylene bottle are suitable, with care that the sample is representative of that section of the stream. For larger streams, where a bridge is suitably located, an enameled pail and rope will provide a sample representative of the surface flow. At such locations, or from a boat, a Kemmerer (*9*) sampler can be used to obtain water from any desired depth.

Concentrations of specific radioisotopes which are considered safe (*3*) are, in a number of cases, not much higher than general water background levels. In addition, as with other industries, waste discharges from nuclear establishments will often be irregular and intermittent rather than continuous, steady discharges having a constant concentration of radioactivity. For these reasons, grab samples of river water at locations below existing industries are not by themselves an adequate measure of the effects of waste discharges. At such locations, composite samples of water are preferable in order to obtain representative results. This is especially true if water samples are the only type to be collected.

One type of automatic sampler installed in a stream below a uranium mill is shown in Fig. 1. The device was modeled after one designed by Trebler (*10*) and modified by the Michigan Water Resources Commission. It operates from a 6-v storage battery and contains a timer, electric motor, gear reducer, and microswitches. The scoop is designed for proportional sampling behind a V-notch weir, but can also be used, as Fig. 1 shows, for ordinary sampling in a free flowing stream. The timer can be set for sampling at various intervals. In the survey from which

Fig. 1 was drawn, grab samples of water were taken at locations farther downstream to supplement the automatic sampler results. Had the stream been larger and deeper, the sampler could have been installed on a float instead of on a fixed platform supported by posts driven into the stream bed. The sampler shown is especially useful and was primarily designed for the direct sampling of industrial effluents, in which case it is generally installed for proportional sampling. Exclusive of labor, this sampler can be built for approximately $100.

A schematic diagram of a different type of automatic sampler, in use at stations on the Ohio River above and below the Shippingport, Pa., nuclear power station (*11*) is shown in Fig. 2. This unit * is designed for continuous sampling of the river water. Approximately 3–4 gal are collected in a week. Once a week the collection jug is emptied, and its contents are assayed for radioactivity.

Aside from considerations of adequate mixing and the half-life of the specific radioisotopes involved, the location of stream sampling points is not so critical a problem as when dealing with organic wastes. Stations below a waste source should be far enough downstream so that the plant effluent is thoroughly mixed with the receiving stream. If the half-lives of some of the discharged radioisotopes are of the same order of magnitude as the time of flow of the river, stations should be located as near the upstream source as possible, and decay of the wastes in passing down to the sampling point should be considered. The farther downstream the sampling point, of course, the lower is the concentration of the waste, making subsequent precise sample analysis more difficult.

The frequency of water sample collection depends on the purpose for which data are to be used. Background samples at uncontaminated locations might be taken at a monthly interval. If grab samples are to be the basis of control at locations below pollution sources, they should be collected as frequently as possible. For better definition of background radioactivity at a specific location, it is planned to make a study of the variability of grab samples taken daily for a limited period of time. As an initial, minimum, background survey of the main stem Ohio River, for example, 50 grab samples were collected at locations in the river basin during a 1-month period (*8*).

For most analytical purposes, 1 or 2 liters of water are usually sufficient and a 1-liter sample will generally be adequate. If precise measurement of background concentrations is desired, then a somewhat larger sample, perhaps 2 liters, may be desirable. For gross alpha and beta determinations a sample of 250–500 ml is generally sufficient. Samples taken below a known pollution source will have higher radioactivity content, hence less sample may be required for gross radioassay. On the other hand, if it is desired to measure specific components of the gross radioactivity at such locations, then the required sample volume may be larger.

Water samples for radioassay need no preservation, and should in no way be altered during or after collection. Most samples will be assayed for gross alpha and gross beta radioactivity. It is often desirable to analyze further for suspended and dissolved fractions of

* This sampler was designed by the Bettis Industrial Hygiene Dept. of Westinghouse Atomic Power Division, Pittsburgh, Pa.

these gross results. Acceptable analytical methods for these determinations are available (*12*), and work to improve them is in progress. Depending upon the particular pollution source, it will, at times, be desirable to analyze for specific components—radium and radiophosphorus have been mentioned as examples. The maximum permissible concentration of radium, for example, is 40 micromicrocuries ($\mu\mu c$) per liter (4×10^{-8} μc per milliliter) (*3*). The maximum permissible concentration for gross alpha radioactivity is 100 $\mu\mu c$ per liter (10^{-7} μc per milliliter). Below uranium mills, therefore, if the gross alpha radioactivity of water samples approaches 100 $\mu\mu c$ per liter, it becomes desirable to determine the fraction which is radium. Each type of industry will generally involve specific radioisotopes whose determination may be of considerable interest. Analytical methods for specific radioelements are generally available if need arises.

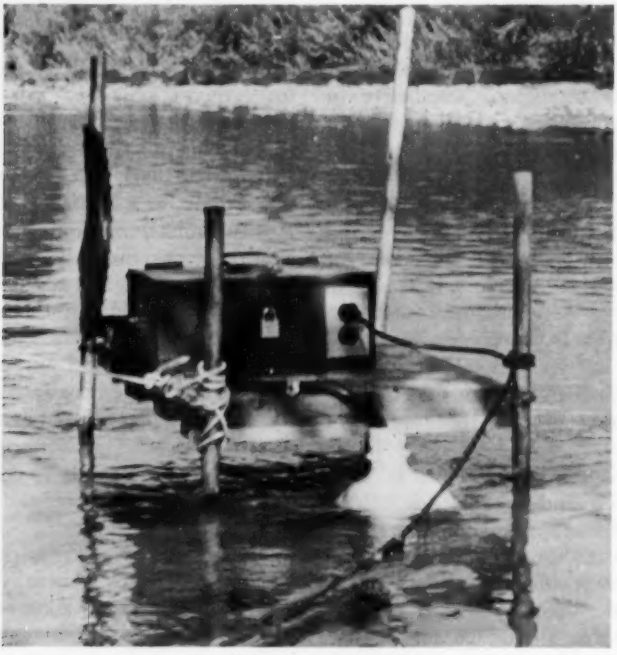

Fig. 1. Automatic Water Sampler

The sampler, located below a uranium mill, was timed to operate every 13 min. The scoop (at left, in upright position) directs water into a 2-gal polyethylene jug (foreground) which is emptied every 24 hr.

Although it is good practice to analyze samples as soon as they are received at the laboratory, it is quite acceptable to delay analysis of samples for radioactivity unless they contain

short-lived material. When the specific contaminant of interest is radium, whose half-life is 1,620 years, for example, there is no reason why a delay of several months between collection and analysis of samples should affect the results. Below the Hanford, Wash., plant, where radiophosphorus is of interest (*6*), samples must be analyzed sooner, as the half-life of P^{32} is only 14 days. The maximum delay between collection and analysis at Hanford was 3 hr. A knowledge of the specific contaminants involved allows one to judge the importance of delays in sample analysis.

Contamination of field equipment such as samplers and polyethylene bottles must also be considered and checked. The scoop of the autosampler shown in Fig. 1, for example, did become contaminated after use below the uranium mill. This necessitated decontamination (soap, water, and vigorous scrubbing) before it could be used again in radioactivity surveys. This would have been even more important had the sampler been used in a more highly contaminated effluent stream instead of in the river after dilution had taken place.

Biological Samples

Another important index of the extent of radioactive contamination of streams is obtained by assay of samples of the stream biota (*13*). During their growth, living organisms, including all of the stream biota, take in and metabolize a wide variety of chemical elements. The extent of uptake varies greatly for different elements, depending upon such factors as availability, chemical form, the needs of the organism, and environmental factors. As a result, the biota can be expected to constitute at least a partially selective sampling device, concentrating certain radioelements to high degree and essentially rejecting others. This selectivity, however, cannot be expected to recur in exactly the same way from stream to stream, because of the differences in waste characteristics and differences in the stream environment.

The radioactivity of an element has no effect upon its chemical characteristics. As a result, the organism has no way of distinguishing between radioactive and nonradioactive isotopes of the same element, and will utilize either isotope without preference, other factors being equal. Phosphorus, for example, a very important nutrient material for living things, is normally present in the nonradioactive form (P^{31}), and is metabolized in that form. At the Hanford, Wash., plant, however, radiophosphorus (P^{32}) is produced in the reactor cooling water, and soon after is discharged into the Columbia River. The plant effluent is carefully regulated so that the concentration of radiophosphorus in the river water is always well below the maximum permissible concentration for domestic water consumption (*3, 6*). Organisms in the downstream habitat, nevertheless, take up and concentrate the radiophosphorus many thousands of times over the water concentration (*6, 14*). Radioisotopes of other elements are similarly taken up and concentrated, although not generally to such a degree as radiophosphorus. Studies of streams below uranium mills indicate that even a heavy metal like radium may be taken up to some degree (*7*). Radiostrontium, too is taken up and concentrated to a considerable degree (*15*).

The radioactivity measured in connection with samples of stream biota

may represent either absorbed or adsorbed material. If absorbed, it is indicative of dissolved or water-soluble radioelements. If it is adsorbed material, it may represent partly insoluble radioelements actually outside the cell walls. Present methods of analysis do not generally permit making a clear distinction here. In either case, if thorough cleaning (washing) of the sample does not reduce its radioactivity, the remaining material becomes an integral part of the life cycle of the stream biota.

Radioelements originally concentrated in plankton (free-floating microscopic animals and plants which may include certain algae and protozoans) will be transferred to aquatic insects such as stonefly, caddisfly and mayfly larvae, and fresh-water snails which feed upon the plankton, and are commonly found on the undersides of rocks. Green filamentous algae may be found as streamers attached to rocks and debris in the stream. Fishes feed on the plankton and aquatic insects, thus completing the stream's feeding chain (Fig. 3). Biota concentration of radioactive material may be derived from the water, as well as by feeding on lower forms. The significance of radioactivity uptake by the aquatic biota can be either very little or considerable. Foster and Davis (*14*), for example, have stated that: "If radiophosphorus were allowed to reach the maximum level permitted for drinking water, organisms living in the water would suffer radiation damage and the fish would be unsafe for human food."

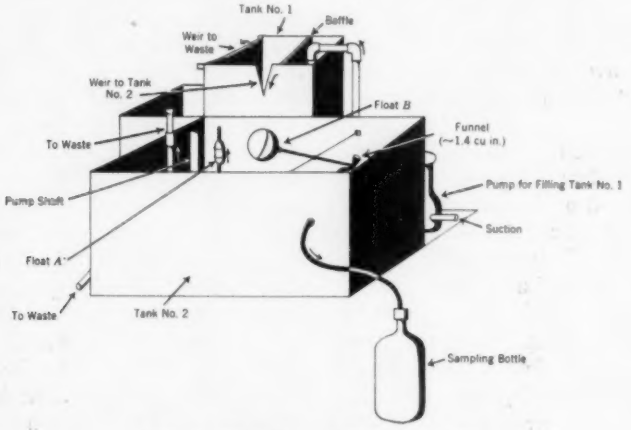

Fig. 2. Continuous Water Sampler

Water is pumped continuously to Tank No. 1, and by means of weirs, is separated so that most of it is discharged as waste. The remainder slowly fills Tank No. 2. Float A *trips a pump to empty this tank when full. Float* B *is mounted on one end of a lever pivoted at its center; the other end holds a small funnel which empties into a flexible tube, which, in turn, leads into a sampling bottle. As the water level rises in Tank No. 2, the funnel dips into the water. When the other float trips the pump, Tank No. 2 is rapidly emptied, and the funnel rises rapidly, delivering its contents into the bottle.*

Depending upon the recent temperture, stream flows and other such factors, a biological sample is cumulative, and represents stream characteristics over a considerable period of time. A grab sample of river water, however, represents only an instant in time. Filamentous algae attached to rocks, for example, may have been growing at that stream location for weeks or even months, continuously absorbing nutrients from the flowing water. Bottom animals, similarly, will have been present for weeks if they are found at all. Although fish are migratory, the range of many species is relatively limited and they, too, can represent exposure of long duration in a limited stream reach. A grab sample of stream biota is therefore really a cumulative sample, and hence very useful at stream locations below sources of radioactive contamination. Because the organisms concentrate to some degree or other many of the radioelements, biological samples are of special value where it is desired to identify specific radioisotopes. In that event, they provide a relatively concentrated sample of small bulk.

For streams that are small enough to be waded, collection of biological samples is direct. Plankton are collected by passing the water through a fine plankton net (*9*) which strains the plankton out of the water and collects them in a small vial. Filamentous algae may be found on rocks and debris in streamers several inches long, and may be snipped off with scissors at a point close to the base of the streamer—the aim here is to avoid scraping if possible, so that the silt which lies near the base of the streamers is not collected. These strands of algae should then be washed free of silt by rinsing in the flowing water. Aquatic insects are obtained by handpicking them off rocks taken from the bed of the stream, or off partially submerged debris. A square foot sampler permits collecting a somewhat standardized sample of the bottom animals (*9*). Fish may be collected by the use of seines, nets, poisons such as rotenone, or by electric shocking devices (in the hands of experts only), if time does not permit the use of more familiar and sportsmanlike techniques.

Larger streams can be sampled by boat, and some of the samples can be collected near the banks. A silk bolting cloth net, for example, was towed behind a boat in the Columbia River studies (*6*) to gather plankton samples, and fish nets of large size were installed in the channel.

Generally, it is desired that biological samples be as representative of the channel as possible. Approximately 2 g, blotted weight, is sufficient material for most analyses. Considerably less will usually suffice if this quantity cannot be obtained with reasonable effort, as is usual with plankton samples. Biological samples should be preserved to prevent putrefaction before analysis—5–10 per cent formalin is adequate for this purpose.

In the location of sampling points, the same general criteria apply for biological samples as were suggested for water, and the two should be collected at the same points. The frequency of collection, especially below pollution sources such as reactors, can be less than that for water samples because of the cumulative nature of the biological samples. The same types of analyses will be desired as for the water samples, and methods for laboratory preparation of biological samples have been described (*6, 12*). The same common sense precautions apply regarding con-

tamination of field and laboratory equipment, and delays between sample collection and analysis have the same significance as for water samples.

Examples of the use of biological sampling include: samples of filamentous algae and bottom animals collected by wading and handpicking in streams below uranium mills of the western United States (*7*); fish samples collected at several locations by poisoning with rotenone, performed by personnel of the Colorado Department of Game and Fish; Columbia River studies (*6*), where all of the types of biological samples were collected by using boats when applicable, large seines and nets for fish collections, and handpicking from rocks and debris along the banks; samples of attached biota, both plant and animal, collected along the banks of the Ohio River by handpicking.

Mud Samples

Another type of sample indicative of stream contamination by radioactivity is the river mud or silt. Radioelements from an upstream source may be deposited on the river bed in two major ways: insoluble materials settling out in reaches of sufficiently low stream velocity; and, as the result of chemical and biochemical alteration of waste constituents, elements coagulating and settling on mixing with the stream water. This type of deposited material is thus different in nature from the radioactivity found with the stream biota and, depending on the character of the wastes, may include radioisotopes essentially absent from the biological samples.

Depending upon the recent flow history of the stream (droughts and flood flows) and its hydraulic characteristics, mud or silt samples may reflect weeks or even months of accumulation of settleable radioactive material. The bottom deposit samples are, therefore, cumulative, compared to the instantaneous nature of grab samples of water. On the other hand, if representative water samples are analyzed for both dissolved and suspended radioactivity, they can provide data for an estimate of the probable amount of radioactivity that will eventually settle. Analysis of the stream's velocity characteristics then provides an indication of the location at which the deposits may be found.

Floods which scour the river bed serve to disperse and relocate radioactive material that has been deposited. This is not an unmixed blessing, however, because it leads gradually to an inordinately heavy deposit of contaminants in the deeper, slower stream reaches where scouring floods occur very infrequently, if at all. The deep pools behind large, high dams are such locations, and some of them may well represent the ultimate resting place of radioactive materials, for all practical purposes.

The studies of stream contamination by uranium mills provide an excellent example of the importance of river mud samples. Such samples, taken for a distance 40 miles below one such ore refinery, indicated significant alpha radioactivity increases at all sampling points. There is little doubt that waste solids from this mill could be tracked a considerably greater distance by means of mud samples. In this way it is possible to form some estimate, not only of existing levels of contamination, but also of the rate of buildup of contamination during the history of the operation of the mill.

Mud and silt samples were collected by wading and direct scooping with a

half-pint mason jar in small streams (*7*). For larger and deeper streams a dredge (*9*) may be used from a boat or bridge. The former is heavier, and more suitable for swifter deep water. Bottom samples are desired, of course, at the same points where water and biological samples are taken. An adequate sample of wet mud is usually ¼–½ pint. Preservation of mud samples is not necessary unless they are largely organic or contain appreciable quantities of sludge worms or other living forms. The frequency of sampling mud is largely a matter of judgment. Mud was sampled once at each station on the third day of a recent 5-day survey below a uranium mill. Muds of the main stem Ohio River and its major tributaries above their confluences with the Ohio were taken a single time in connection with the initial minimum background survey of that stream (*8*). Mud samples had to be taken near the river banks, as boats were not available at most sampling stations.

As has been noted, biological and mud samples are cumulative in nature, whereas grab samples of river water are instantaneous. Infrequent grab samples of water, taken alone, are not adequate for purposes of radioactive waste control. If automatic water sampling equipment is not available, however, grab samples of water, taken in conjunction with adequate biological and mud sampling, can provide sufficient data for adequate interpretation in terms of stream conditions.

Background Activity

Stream samples taken at locations which are uncontaminated by any upstream local source of radioactivity will nevertheless contain a small quantity of radioactive material. This is the radioactivity "background." Prior to the development of nuclear weapons, this radioactivity was entirely derived from radioelements such as uranium, thorium, radium, and potassium 40, occurring naturally in the earth's crust. The geographic distribution of these natural radioisotopes is quite variable; in a few locations, deposits are rich enough to mine economically, and some hot springs in the western United States contain relatively high concentrations of radium. The natural background radioactivity of surface waters can thus differ considerably from one river basin to another.

With the advent of nuclear weapons and their testing, a second source of background radioactivity—the fallout from these tests—was added. The effects of this source on local stream background measurements are quite unpredictable, depending on the intermittent occurrence and type of worldwide weapons tests, and on meteorological factors such as wind currents and directions, and rainfall. Most of the fallout has beta and gamma radioactivity. As a result of this added general source, the gross beta background radioactivity of surface waters is now somewhat higher than it was a decade ago (*17, 18*). This increase is slight, but as tests of atomic weapons continue, further slight increase in background radioactivity is likely to occur.

Background radioactivity at any stream location or in any drainage basin is variable, depending upon the natural radioactivity, the amount of old fallout on the drainage area, and fallout from recent weapons tests (*19, 20*). The gross background radioactivity content of surface waters will usually be less than the maximum permissible concentration for gross radioactivity content

(100 $\mu\mu$c per liter) (*3*), but occasionally values slightly higher may be found, as for example, following recent weapons tests or recent rainfall (*6, 20*). In order to be able to interpret properly the results of analysis of isolated samples or small numbers of samples, a knowledge of the variability of background is essential. This knowledge can be built up only by experience from analysis of a sufficient number of samples by state and local agencies so that local stream background radioactivity may be charted, and eventually, enough local data can be collected to develop an estimate of the areawide and national background of surface waters. This task cannot be long delayed in view of the rapid and wide development of the nuclear industry and the continuing need to test atomic weapons.

Control of waste discharges from existing and contemplated nuclear establishments, as previously mentioned, should be based upon consideration of the whole stream environment and the whole range of existing and future water uses. Adequate control is based on three types of stream sample—water, aquatic biota, and bottom deposits—rather than upon water samples only. Very little to nothing is known at present about existing radioactivity background levels for bottom deposits or the stream biota.

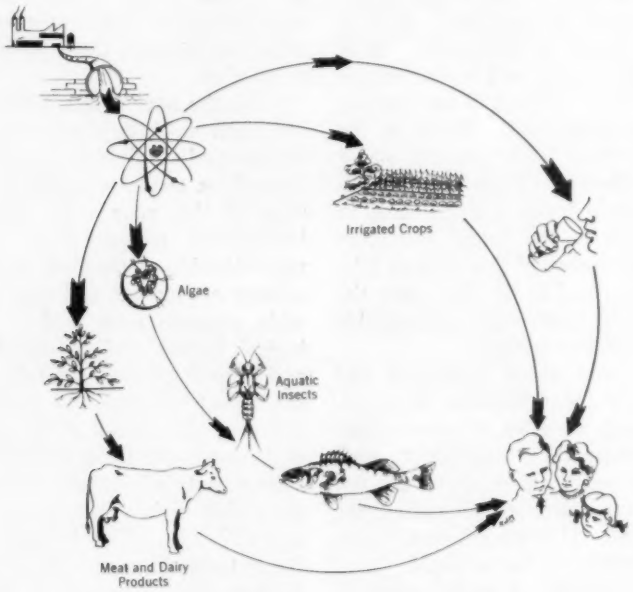

Fig. 3. Radioactive Wastes From Water to Man

Indiscriminate general monitoring of streams is not suggested in determining background activity. Stream sampling points for this purpose should be judiciously selected, keeping in mind the following factors: existing and planned water uses; domestic water intakes;

present and probable locations of nuclear plants; and areas that are not likely to become involved with nuclear plants in the near future. A minimum number of such sampling points of local importance should be selected, in keeping with the funds and personnel available. These locations for sampling are obviously best selected by the state water pollution control agency, and stations will undoubtedly be added to and deleted from the initial set as the program progresses and develops.

The frequency of background sampling is again a matter for local judgment based on immediate and long-term need, and the scope of the program. At some locations, monthly grab samples of water will be desired, while at others, such as domestic water intakes, more frequent or composited samples may be easily obtained. Biological and mud samples, being cumulative in nature, might be needed less frequently, except for the dearth of data on these types. Monthly samples are therefore suggested at the start. As information accumulates, it may well prove desirable to alter these frequencies of sample collection and analysis.

Initially, gross assay (alpha and beta) of samples will be adequate. At some future date, identification and counting of one or two specific radioisotopes may become desirable at a specific sampling point because of anticipated wastes from a new industry. This should be the exception, at least for some time, and gross assay of background samples should generally suffice.

Hydrologic Data

It is important in any stream survey for pollution control to know the quantities of waste materials as well as the concentrations. It is especially necessary to be able to predict maximum concentrations that may occur. Accordingly, at stream locations where a nuclear plant exists or is planned, studies of low-flow frequencies for the stream are required. They will be used to estimate total quantities of wastes present, to predict maximum expected concentrations, and to estimate minimum available dilution.

The necessary stream flow data for flow frequency studies are usually available from the US Geological Survey, or through cooperation with that agency, and methods of data analysis have been developed (*21*). As with more ordinary pollutants, the best time for radioactivity surveys involving a definite pollution source is in mid to late summer at most locations. At that time stream flows are generally low and the development of biological life such as algae is at a peak.

Effluent flows should be obtained at the time of survey, in conjunction with stream flows. The data may be available from the industry involved, but more often must be obtained by the survey party. The effluent flows are necessary, of course, in estimating the quantity of waste material discharged to the stream during the general stream survey. A daily hydrograph of stream flow for the several months including and immediately preceding the survey is of great value in estimating the recent occurrence of high flows which might have scoured the stream bed and torn algae and other biota loose from their moorings. In a recent survey of a stream near a uranium mill, for example, it was proved of great value in data interpretation to know that the survey was preceded by approximately 3 weeks of very low flow (approximately 20 cfs), but that there had been a flash flood (approximately 3,000 cfs) just prior to this drought.

Recent rainfall records are of value when dealing with both stream survey and background data interpretation, as rainfall may bring down fallout from recent or older weapons tests, and will wash into the stream some of the fallout already deposited on the drainage area. Rainfall records can usually be obtained from a nearby weather station or local airport. No stream radioactivity survey will be complete without having given attention to hydrologic data.

Discussion and Summary

Every stream radioactivity survey has its own special features, and each problem of stream contamination by radioactive wastes is distinctive. No two stream surveys for radioactive waste control, therefore, are likely to be quite the same in detail. An obvious example is the way in which specific radioisotopes (radium, radiophosphorus, fission products) affect the types of sample to be emphasized, types of analysis required, survey duration, and other factors. I short-lived radioisotopes are involved, a field laboratory may be required. The hydrologic features of each stream are different, and may affect the timing and course of the survey. The source of waste and the specific radioisotopes of concern will usually be known in advance. In general, then, each stream survey for radioactive waste control must be planned and executed as an individual problem different from most if not all others.

It is important to know the characteristics of the plant effluent, and a significant part of any stream radioactivity survey should be devoted to sampling and gaging effluent flows (*22*). If at all possible, the entire survey should be performed during a period of normal industrial plant operation in order to obtain truly representative results, and consideration should be given to the occurrence and effects of weekend load fluctuations, work stoppages, and holidays, as these may temporarily alter the plant effluent picture.

The three distinct types of stream sample (water, mud, aquatic biota) are all of importance. Each yields information not derivable from the other two, and no one type should be neglected if an adequate interpretation in terms of the extent and effects of stream contamination is desired. Of the three types, the biological samples are perhaps the most difficult to obtain, but in estimating the effects and significance of stream contamination, their importance is clear.

The duration of any individual survey will depend especially upon its importance and its major purpose. A great deal of information can be obtained in a brief intensive survey of, say, 10 days, if planning is thorough and complete. On the other hand, seasonal variations of temperature, stream flow, and predominant biological species, may be of importance, requiring either an extensive, long survey or a series of briefer field studies. Background radioactivity levels cannot be determined once and thereafter serve for all time, but must be checked regularly and indefinitely in order to follow local and national changes and trends.

There is some question as to the desirable degree of precision in analysis of samples, and its effect in the general problem of selecting adequate instrumentation and analytical methods. Gross background radioactivity levels generally are not much greater than the degree of precision obtainable by analytical methods suitable for routine use. In the case of background samples, therefore, the analytical method

and laboratory instrumentation should be selected for maximum precision in keeping with reasonable cost, personnel time, and other obvious factors. When detection of suspected contamination is the primary aim of sample collection and analysis, however, may not be necessary to strive for the maximum possible precision in analysis. If significant contamination exists, coarser, more rapid and economical analytical methods will generally suffice. Where identification and measurement of specific radioisotopes, rather than gross radioassay, is desirable, the question becomes largely one of sufficient precision.

Continuous monitors for radioactivity in water can be very useful. An instrument capable of continuously detecting and recording radioactivity concentrations at the background level would be useful, but is not now generally available. The necessary level of precision in detecting radioactivity continuously would make such a device relatively expensive. On the other hand, a continuous monitor for nuclear plant effluents, capable of detecting radioactivity levels of, perhaps, 100 or 1,000 times background, would also be very useful, and should be obtainable at a practical cost. Such an instrument, connected with an alarm system, could serve as an emergency monitor for rapid detection and warning of accidental spills in the plant; equipped with a recorder, it would maintain a quite valuable record of plant operation. In order to operate effectively, such an alarm system must be supplemented by an arrangement between industry, the regulatory agency, and downstream water users, for direct and rapid notification of accidents and warning to take necessary action.

The same general principles apply to the control of radioactive wastes as apply to the control of other water pollutants, and the stream survey is a key control device. No general handbook method for stream radioactivity surveys exists and, because of the special features of each individual radioactive waste problem, none should be expected. In this as in other types of stream survey for pollution control, the most efficient and adequate performance has its basis in common sense and in judgment based upon training and experience.

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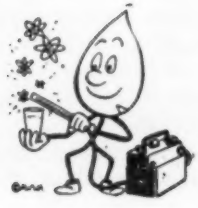

Radiochemical Procedures for the Identification of the More Hazardous Nuclides

Bernd Kahn and Abraham S. Goldin

A paper presented on Mar. 11, 1957, under the joint sponsorship of AWWA and ASCE, at the Engineer Joint Council's Nuclear Eng. and Science Congress, Philadelphia, Pa., by Bernd Kahn, Chief Chem. Engr. (assigned to Oak Ridge National Lab., Oak Ridge, Tenn.), and Abraham S. Goldin, In Charge of Radiochemical Methods; both of the Robert A. Taft San. Eng. Center, USPHS, Cincinnati, Ohio.

THE mere determination of the quantity of radioactivity in a medium is not an adequate measure of the damage or hazard that may be expected. Such damage can be estimated only on the basis of the biochemical and physical properties of the radionuclides present. The rate of dosage an organ receives from ingestion depends on the quantity ingested, the fraction reaching the critical organ, the effective energy, the effective half-life, the time of exposure, and the mass of the critical organ (1). Using an equation which takes all these factors into account, one can calculate, for example, the dose rate to bone from continuous long-term ingestion of three different radionuclides in water—strontium 90, phosphorus 32, and molybdenum 99. For a 40-year ingestion of these three isotopes at a level of 100 micromicrocuries ($\mu\mu$c) per milliliter (10^{-4} μc per milliliter), or 1,000 times the maximum permissible concentration for isotopes of unknown composition, the respective bone dose rates would reach: 11 rem * per week for strontium 90; 0.033 rem per week for phosphorus 32; and 0.000002 rem per week for molybdenum 99. These values may be compared with the occupational dose of 0.3 rem per week. It thus appears that strontium 90 is approximately 300 times as toxic as phosphorus 32 and approximately 5,000,000 times as toxic as molybdenum 99. While these values would be somewhat modified if exposure to the intestinal tract were also considered, they serve to illustrate the difference in dosage resulting from ingestion of equal amounts of activity of different nuclides.

It is evident from this that the measurement of gross activity alone does not adequately evaluate the radioactivity problem; a knowledge of the particular radioactive materials present is also necessary. In a mixture of the three isotopes considered in the previous example, a determination of the strontium 90 activity would be far more significant than a gross activity determination. The "less hazardous" isotopes are not to be neglected, and it should be remembered that the goal is to avoid, insofar as possible, *any* significant contamination of the environment.

In addition to its radiotoxicity, a nuclide may be significant because of its abundance. The more abundant

* "Roentgen equivalent, man"—the dose of any ionizing radiation which produces the same biological effect as that produced by 1 roentgen of high-voltage x-radiation.

radionuclides include: major fission products and heavy elements inevitably resulting from the operation of nuclear reactors; naturally occurring radioelements; and some radionuclides produced in quantity because of their usefulness. Table 1 lists some of the radionuclides considered important because of their low maximum permissible concentrations (high toxicities), their abundance, or both. An examination of Table 1 will show that the hazard of these radionuclides varies over an extremely wide range, the maximum permissible concentrations ranging from 40 $\mu\mu$c per liter for radium 226 to 2,000,000 $\mu\mu$c per liter for both cesium 137 and niobium 95.

Identification Methods

The identification of a radionuclide may be based on chemical separation (including separation of a daughter activity) or on radiation characteristics such as half-life, type (alpha, beta, or gamma), or energy. In general, a combination of chemical and physical methods will prove more efficient than either approach alone. In many cases, however, because the isotopes involved are present at extremely low levels, determination of radiation characteristics may not be practical.

At low levels, which may be below the maximum permissible concentration, it is usually necessary to concentrate the activity from very large samples. At still lower activity levels, or where large samples are not available, extremely specialized counting equipment must be used, in which the background is lowered to mere traces by the use of heavy shielding and anticoincidence circuitry.

Preliminary preparation is a major problem with many types of samples. Current procedures for the analysis of solid samples usually call for total dissolution: soil is treated by carbonate fusion and then dissolved in acid (*4*); biological material is either wet- or dry-ashed and then dissolved (*5*).

Although radiochemical separations based on common analytical procedures have been published for every element (*6–8*), it is still necessary to modify the methods to permit measurement at the low levels of activity which exist and to permit application to different media. Often, especially when dealing with soils and biological materials, separation of the desired radionuclide from a large mass of inert matter is the most difficult chemical problem. These inert materials are not usually considered in the methods referred previously, which have dealt with such materials as pure neutron-irradiated uranyl nitrate solutions, cyclotron bombardment targets, and the like. A problem of radiochemical separation worthy of special mention is the presence of the radionuclide in different chemical states—methods which have proved satisfactory when tried on radiotracer solutions may fail in the analysis of insoluble materials or material in unexpected valence states.

In radiochemical separation techniques, a known quantity of carrier material is usually added so that the radioisotope (usually present in such small amounts that it cannot be weighed) can be manipulated. The recovery need not be quantitative, as the results can be corrected for chemical yield on the basis of the recovery of the carrier. Rapid, nonquantitative, methods can, therefore, be used. The following methods developed for determination of specific radionuclides at low levels in water or soil are representative of some of the sample preparation, chemical separation, and count-

ing procedures generally used. Their sensitivity, for 30-min counting on high-efficiency conventional counting equipment, is of the order of 10 $\mu\mu$c for beta emitters and 1 $\mu\mu$c for alpha emitters.

Radium 226 (9)

To a 1-liter sample are added 200 mg lead and 5–10 mg barium as carriers for the radium, along with sufficient ammoniacal citrate to prevent precipitation of the carriers before interchange with the radium has occurred. Their sulfates are then precipitated with sulfuric acid, and the precipitate collected by decanting. The sulfate precipitates are washed with concentrated nitric acid, and then dissolved in ammoniacal ethylenedinitrilo tetraacetic acid. Barium sulfate, carrying the radium, is reprecipitated by the addition of excess acetic acid. The precipitate is washed, mounted, dried, flamed, and weighed.

Radium content is determined by alpha counting. The radium may be checked for radiochemical and isotopic purity by following the growth of radon 222 and its daughters in the precipitate.

TABLE 1

Some Hazardous Radionuclides

Nuclide	Origin	Maximum Permissible Concentration in Water*		*pMPC*$_w$†
		μc/ml	$\mu\mu$c/l	
Ra^{226}	natural	4×10^{-8}	40	7.4
Unknown	——	1×10^{-7}	100	7.0
Sr^{90}	fission product	8×10^{-7}	800	6.1
Po^{210}	natural	3×10^{-6}‡	3,000‡	5.5
U^{233}	irradiation	3×10^{-6}‡	3,000‡	5.5
Pu^{239}	irradiation	3×10^{-6}‡	3,000‡	5.5
Am^{241}	irradiation	3×10^{-6}‡	3,000‡	5.5
I^{131}	fission product	6×10^{-5}	60,000	4.2
Sr^{89}	fission product	7×10^{-5}	70,000	4.2
Ca^{45}	irradiation	1×10^{-4}	100,000	4.0
Ru^{106}	fission product	1×10^{-4}‡	100,000‡	4.0
Ce^{144}	fission product	1×10^{-4}‡	100,000‡	4.0
P^{32}	irradiation	2×10^{-4}	200,000	3.7
Co^{60}	irradiation	4×10^{-4}	400,000	3.4
Nb^{95}	fission product	2×10^{-3}	2,000,000	2.7
Cs^{137}	fission product	2×10^{-3}	2,000,000	2.7

* All values marked "‡" are taken from Morgan and Ford (*2*); all others are from the Recommendations of the International Committee on Radiological Protection (*3*).

† In addition to the conventional maximum permissible concentrations, expressed as μc per milliliter or $\mu\mu$c per liter, a comparative measure of toxicity, pMPC$_w$, is introduced. This quantity, which is analogous to pH in that it is defined as the negative logarithm of the concentration (expressed in μc per milliliter) is offered as a convenient unit, with the advantages of eliminating the exponential notation and of using a larger, rather than smaller, number for the more toxic nuclides.

‡ One-day values causing damage to intestinal tract (*2*).

Strontium and Barium (10)

To a 4-liter sample are added 20 mg each of strontium and barium carriers, and carbonate is added to precipitate strontium, barium, and calcium carbo-

nates. The nitrates of strontium and barium are precipitated in strong nitric acid and the small amount of calcium nitrate also precipitated is dissolved out with anhydrous acetone. Contaminating activities are removed by adding ferric iron and precipitating the hydroxide. The barium and strontium are then separated by precipitating barium chromate from a buffered solution. Strontium oxalate is precipitated, dried, mounted, weighed, and counted. Barium is further purified by precipitation with hydrochloric acid-ether, dried, mounted, weighed, and counted.

Strontium 90 (11)

To a 1-liter sample is added 400 mg of strontium nitrate carrier. Sodium carbonate is added to precipitate the strontium, together with calcium in the water. The precipitate is collected by decanting and redissolved in dilute acid. Barium carrier is added and precipitated as chromate from an acetic acid-acetate buffer (pH 5) to remove barium 140 (which will interfere subsequently because of its lanthanum 140 daughter). Ferric ion is added and precipitated with ammonia, carrying insoluble hydroxides, including the rare earths. Rare-earth and zirconium carriers are then added and precipitated with ammonia, to remove interfering activities more completely. The strontium is then precipitated from the supernatant solution with carbonate and allowed to stand overnight (or longer) to give time for the ingrowth of yttrium 90. The solution is then buffered at pH 5 and yttrium extracted with 2-thenoyltrifluoroacetone (TTA) in monochlorbenzene. Yttrium 90 is back-extracted from the organic phase into dilute nitric acid, mounted, and dried. The chemical yield of strontium is determined by flame spectroscopy.

The strontium 90 is determined by beta counting the yttrium 90 and correcting for the fraction of yttrium which had grown into the strontium sample. Yttrium 90 activity reaches 16 per cent of the strontium 90 activity in 16 hr, 40 per cent in 48 hr, and 84 per cent in 168 hr. Purity of the yttrium 90 may be readily checked by decay measurements.

Cesium (12)

To a 1-liter sample are added 25 mg cesium chloride and 200 mg potassium chloride carriers. Cesium and potassium are then precipitated as cobaltinitrites from acetic acid solution. The precipitate is collected by decanting, washed with 10 per cent acetic acid, and dissolved in 6*M* hydrochloric acid. Silicotungstic acid is added to precipitate cesium silicotungstate, thus separating cesium from the other alkalis. The precipitate is washed with 6*M* hydrochloric acid and dissolved in sodium hydroxide. Perchloric acid is added and the solution heated and centrifuged to remove the oxides of silicon and tungsten. The perchlorate solution is cooled, and absolute alcohol added to precipitate cesium perchlorate, which is washed with alcohol, mounted, and weighed.

The content of cesium 137 or cesium 134 is determined by beta or gamma counting.

Iodine 131

Iodine is determined essentially by the method of Glendenin and Metcalf (*13*) applied to large samples. Carrier sodium iodide is added, oxidized with sodium hypochlorite in basic solution, reduced to elemental iodine, and extracted into carbon tetrachloride. The iodine is then back-extracted into sodium bisulfite solution and precipitated

as silver (or palladium) iodide for beta counting.

An alternate method is to count the gamma photons of either the carbon tetrachloride or sodium bisulfite extracts in a scintillation counter, thus eliminating the rather troublesome handling of silver iodide, which tends to be colloidal.

Cobalt 60 (From Soil) (14)

To 10-g soil samples leached with dilute nitric acid, cobalt carrier is added and precipitated as hydroxide. The precipitate is dissolved in acetic acid and cobalt is reprecipitated as potassium cobaltinitrite. This is redissolved, and cerium carrier is added and precipitated with ammonia to remove contaminating activities. Cobalt is again precipitated, as the 1-nitroso-2-naphthol salt, ignited to oxide, mounted, weighed, and the beta particles are counted.

Future Work

Methods of analysis are currently being developed for other isotopes, particularly among the fission products. Improvements in methods of sample preparation for nonaqueous media, in particular foods and other biological materials, are also being studied.

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Butterfly Valve Design and Application

Henry C. Schwenk

A paper presented on Oct. 26, 1956, at the Chesapeake Section Meeting, Baltimore, Md., by Henry C. Schwenk, Valve Sales Mgr., Henry Pratt Company, Chicago, Ill.

THE butterfly valve has been used since ancient times as a practical device for the control of fluids. In modern usage, it has passed from the use of light-weight dampers for control, to the use of metal seat valves in which the disc is wedged at an angle to the body in an effort to minimize leakage. This development was followed by the disc arm pivot valve method which assisted in obtaining tight shutoff in metal seat valves, and, finally, by the present high-quality rubber seat butterfly valves which can be obtained to AWWA specifications from five to six different manufacturers.

A great deal of information concerning the design of butterfly valves has been published in recent years. The valve manufacturers have expended much time and energy on technical literature designed to provide industry with background material and up-to-date design information. The AWWA has, as is well known, approved two excellent specifications (*1, 2*) designed to guide the water works industry in the selection of butterfly valves for common applications.

An explanation of some butterfly valve design considerations is extremely helpful in understanding this valve type, in applying it properly, and in specifying it wisely. Several theoretical concepts are involved, and a sound knowledge of them can lead to important savings in applying the butterfly valve to a water-handling problem. Although butterfly valves are basically a simple device, their nature makes them subject to forces not common to most other valve types. It is important, therefore, to discuss briefly the characteristics of the butterfly valve (specifically, the rubber-seated type which has recently come into popular use in certain applications within the water works industry) and the effect of flow conditions on it.

The question of the forces subsumed in line or flow conditions and their effect on valve construction is the aspect of butterfly valve selection most puzzling to the prospective valve buyer, who wonders why he cannot simply specify a 25-psi valve when that is the maximum pressure he expects to encounter. An investigation of the influence on valve design of these forces should explain the apparent anomaly.

The basis for considering line dynamics when using butterfly valves is the fact that the butterfly is not a balanced valve. An unrestrained butterfly valve disc under flowing conditions will go to the closed position. This is an elementary fact, and is true regardless of the direction of flow with respect to valve orientation. This tendency to close under flow conditions gives a clue to the nature of the flow torque and to a means for calculating it. Flow torque, or fluidynamic torque as it is called, can best be explained by likening it to the "lift" experienced by an airplane wing exposed to an airstream.

The lift on the wing is due to an unequal pressure distribution on the wing surfaces caused by uneven flow patterns around the airfoil section. On an airplane wing and on a valve disc, the lines of flow tend to take the easiest path around the obstruction, giving rise to the unbalance in force. On a butterfly valve disc, the center of this unbalance occurs at some fixed distance from the shaft centerline. This force, multiplied by its distance from the centerline, equals the fluidynamic torque. The magnitude of this force and, hence, the magnitude of the torque, is dependent on a mathematical relationship between the valve diameter, flow velocity, angle of the valve disc, and pressure distribution across the valve. Its peak usually occurs between disc angles of 30 deg and 80 deg. Equations developed from experimental flow data enable the prediction of this torque quite accurately.

The other special forces bearing consideration in rubber-seated butterfly valve design are seating torque, bearing friction torque, and hydrostatic unbalance torque.

Seating torque, as its name indicates, is the torque required to rotate the valve disc into the rubber seat. Its magnitude depends only on valve diameter and the seat material, and is a constant for any particular valve design.

Bearing friction torque is the frictional resistance to rotation imposed on the valve shaft by the bearings and shaft seal. It is a function of the pressure differential across the valve, multiplied by a constant for any particular valve. This constant, in turn, depends on valve diameter, shaft diameter, and the frictional coefficient between the valve shaft and bearings.

Hydrostatic unbalance torque exists only when a large valve in water service is mounted in a horizontal pipeline with its shaft horizontal. This torque is the result of the hydraulic gradient from top to bottom of a full pipeline, producing an off-center action on the valve disc, with resultant unbalanced torque. This unbalance, while easily determined, is a special case and need not be considered in this discussion.

The torques just discussed do not occur haphazardly in the operating cycle, but have certain fixed relationships with disc position and pressure differential across the valve. Fluidynamic torque, for example, varies with the angle of the valve disc and with pressure drop across the valve. Bearing friction torque varies with the pressure differential. Seating torque is a fixed value for any given valve size and occurs only in the closed position.

In approaching any given valve problem, a detailed knowledge of actual operating conditions must first be acquired. The values of the dynamic, bearing friction, and seating torques are then calculated. It is easy to see that the dynamic torque occurs only when the valve is off its seat, opening or closing, or at a control point, and that there is bearing friction to be overcome at this time because of upstream pressure against the valve disc. Similarly, it is evident that as the valve is being seated, the line pressure against an almost closed disc (which presents the full disc area for the pressure to work on) will produce a maximum value of bearing friction torque which is added to the seating torque.

After the dynamic torque is calculated the bearing friction torque is computed at the angle at which dynamic maximum is occurring. Addition of these values gives the first torque maximum, which can be designated *Ta*.

Adding the seating torque and the bearing friction torque at closing gives a second torque maximum, *Tb*. The larger of the two (*Ta* or *Tb*) is then

the value which is used to establish an operator size. Most leading manufacturers have made this torque-computing job easier for their sales personnel and customers by putting it in tabular form, by using a special slide rule, or by standardizing it by furnishing only "safe" operator sizes. The latter course is the one adopted in the AWWA specification (*1, 2*) with its use of the minimum torque values as outlined in the torque tables of those specifications.

This brief outline of the effect of line conditions on butterfly design and operator selection should help make clearer the reasons why each butterfly valve application should be analyzed completely before a recommendation can be made. Each such recommendation involves experimentally validated technical experience and a thorough knowledge of the application. The valve manufacturer can supply the experience, but complete information about the application can come only from the engineer or purchaser.

Those who have dealt with or investigated the use of rubber-seated butterfly valves, know that the AWWA has set up three pressure categories for the valves and, within each category, two velocity limitations. The six resulting valve classes are labeled 25-8, 25-16, 50-8, 50-16, 125-8, and 125-16.

The first number in the designation is the pressure rating in pounds per square inch, and the second, the velocity rating in feet per seond. These classes were arbitrarily set up with the thought that they would cover the majority of water works applications and, if used properly, protect the user in insuring that he had the proper valve for the job. The pressure-velocity method of rating uses the methods just discussed —that is, it is a way of relating valve design to a set of maximum flow conditions for that class of equipment. This means, for example, that a 25-8-class valve is designed for shutoff at 25 psi and operation at 25 psi with pipeline valve is designed for shutoff at 25 psi level. This does not mean that 8 fps is a maximum velocity but, rather, that the pressure and velocity are together a parameter in this given design. If, therefore, the maximum pressure level is 15 psi, the velocity handled can be in the vicinity of 10 or 12 fps. This point is often confusing to the prospective valve user, and it has been the author's experience that many believe that an AWWA butterfly valve should not be used in velocities greater than 16 fps.

At the present time there are rubber-seated butterfly valve installations operating at velocities up to 40 fps. These valves, essentially AWWA types, are being used without exceeding conventional machine design safety factors. It is recommended, however, that, because of the possibility of cavitation such an application, the installation under consideration be discussed with reputable manufacturers in the industry.

Conclusion

The rubber-seated butterfly valve has been in use in water service in the power field since 1926. It is the author's expectation that it will yet assume a position where it can assist the gate valve, sluice gate, plug, ball, and cone valve in doing a good job for the water works industry.

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Automation in Recent Water Purification Plants

Ellwood H. Aldrich

A paper presented on Nov. 8, 1956, at the Virginia Section Meeting, Old Point Comfort, Va., by Ellwood H. Aldrich, Chief Engr., American Water Works Service Co., Philadelphia, Pa.

THE term "automation" has come to have a wide range of meaning in the past few years. The concept, not basically new, even though the word is not in the dictionary, is a result of the evolution from the era of manual labor, through the power, mechanical, and electrical age, to the automatic control of productive processes by electrical, hydraulic, or pneumatic means.

During the past few years it has grown by such leaps and bounds and to such an extent that most water works men have been unable to keep up with many of its ramifications. It is the result, largely, of technological development, fathered by the necessity to combat rapidly mounting costs (chiefly labor), and stemming from the desire constantly to improve the product.

Automation is not to be confused with "instrumentation," another common word of today. Instrumentation may be, and usually is, an important element of automation, providing the sensing and activating mechanisms by which the automatic operations can be controlled.

Devices Available

Transmission, control, and evaluation elements for automatic operation are available. In the water works profession, sensing devices are offered for measuring chlorine residual, pH, oxidation-reduction potential, conductivity, pressure, temperature, liquid level, and fluid flow. Devices to measure and record on a continuous basis, turbidity, color, hardness, chlorine and fluoride residuals, and sludge densities are far advanced. Complete automation will involve automatic analyzers and computer mechanisms in the laboratory as well as means for translating the results into action in the treatment process. Safeguards for such operations may require the use of photoelectric cells, X-ray microscopes, and closed-circuit television, among other things.

With increasing frequency, the principles of automation are being systematically applied in many fields of water production. While automation has many worth-while advantages, it is important to recognize some possible shortcomings. Ralph Cordiner, president of the General Electric Company, recently remarked in a newspaper interview * "All of this talk of a pushbutton plant is plain poppycock. Neither you nor I will live to see such a plant"—that is, a completely automatic one. He further observed that with every expansion of automation "more and better-trained workers will have to be hired to run it from behind the scenes."

* Philadelphia Inquirer, Oct. 14, 1956.

Recent Automation Applications

No attempt will be made here to cover the full field of automation in the treatment plant. A few of the automatic processes which have been incorporated in some recently constructed water treatment plants will be described, but these constitute hardly more than a start along the road of automation.

It might be pointed out that such a start was fostered by a tendency away from the conventional treatment plant to new approaches in design and construction. For a number of quite forceful reasons—one of the major ones being the increasing costs of construction—there were developed approximately 7 years ago at Alexandria, Va. (*1*), what have been termed purification units; each of these units, of steel construction, accomplishes the three principal steps of treatment—mixing, settling, and filtration—in individual units which are grouped as desired and located outside and remote from the point of control of operation. It became necessary, therefore, to develop proper means of instrumentation and control which would satisfactorily perform at a remote location the several steps in the operation of the treatment units.

Alexandria Pilot Plant

As exemplified in the Alexandria plant, the remote control of the filters consists of a pneumatic-hydraulic system of operation which, actuated by a single pushbutton, withdraws the purification unit from service, washes the filter, and returns the unit to service automatically.

The plant at Alexandria was a pilot plant. In 7 years of operation, during which two additions have doubled original capacity, performance has been sat-

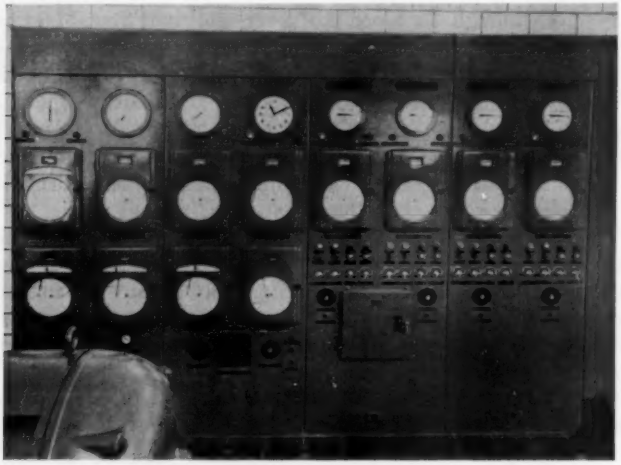

Fig. 1. Typical Panel Board Used in Automatic Treatment Plant Installations

The panel board shown is part of an installation at the Beaver Run plant at Westmoreland County, Pa.

isfactory. It is believed that the original aims of reducing costs of construction and operation have been accomplished. The complete filter plant, with a nominal rating of 17.6 mgd, including high-service pumping station and equipment, will have cost less than $70,000 per million gallons of daily capacity, adjusted to the 1956 construction cost basis. The lower cost of instrumentation and control contributed materially to the low overall cost. At the same time, the ease of operation of the units made possible the complete operation of the station with one man per shift, assisted during the day with casual labor for handling chemicals and general plant and grounds maintenance.

Purification Units

The purification units, now numbering eight, each with a rating of 2.2 mgd, employ conventional treatment processes. Chemicals are added as required, followed by mixing, coagulation, settling, filtration, chlorination, and pumping. The control building is the center of operations. It houses the chemical storage and feeding equipment, high-service and wash water pumping equipment, laboratory and service rooms, as well as the control panels for filter and pump operations.

The purification units are controlled from a panel board of the type shown in Fig. 1. The controls function pneumatically to operate hydraulic valves located in a valve house situated between two units. The valve houses are the only place where the major filter piping is exposed. When the loss of head in the filter unit reaches a predetermined level, an alarm rings and a light indicates that the filter requires washing. The operator, at his convenience, pushes a button which starts a program timer. This timer actuates pneumatic relays which open and close the various filter valves to start the wash cycle. An interlock is provided so that each valve in the sequence must be fully opened or closed as required before the next valve functions. As the wash water valve starts to open, the wash cycle begins. Filters are washed in three stages. The initial wash is at a low rate in order to raise and break the bed gently and agitate the sand, the second stage is at a high rate to clean the sand and wash the foreign material into the wash gullet, and the third stage returns the wash flow to the low rate to grade the sand bed hydraulically. The length of time for each stage is adjustable at the control panel. Similarly, the rates of wash can be manipulated through adjustment of the wash water controller which is located in the wash line. When the wash cycle is completed, the program timer completes the cycle of valve operation to return the unit to service.

Once the operator has pushed the button to start the program, he need no longer give his attention to the operation, but can go about his other duties. If he wishes to observe the results of the washing operation, he can go to the unit where the filter bed is completely exposed for his observation. He can prolong the wash cycle at the unit by means of a manual station located for that purpose.

The control panel also contains remote rate-setters for changing individual filter rates as desired. These operate on the rate-of-flow controllers located in the valve houses. Recording loss-of-head and rate-of-flow gages having weekly charts record the operation of the units.

Not only may the units be operated manually at the control board, but manual hydraulic controls are provided in

the valve houses to operate the various hydraulic valves if necessary. Compressed air for the pneumatic controls is furnished by small air compressors and storage tanks in duplicate located behind the control board.

In this installation, there has been no attempt to regulate automatically rates of feed of chemicals and chlorine. Chemical and chlorine feeders are generally adjacent to the laboratory or control room, at a convenient location for the operator to control the treatment.

Other Installations

Following the original installation at Alexandria, similar types of purification units have been installed at Chattanooga, Tenn. (20 mgd), Ashtabula, Ohio (4 mgd), Westmoreland County, Pa. (10 mgd), Long Branch, N.J. (2 mgd), Lemoyne, Pa. (2 mgd), Kokomo, Ind. (4 mgd), Canonsburg, Pa. (4 mgd), Huntington, W.Va. (5 mgd), Greenwich, Conn. (4 mgd), and East St. Louis, Ill. (10 mgd). Under construction is a 10 mgd plant at Summit, N.J., and in progress or planning are plants at Lexington, Ky. (4 mgd), and Peoria, Ill. (10 mgd), and further extensions at East St. Louis, Kokomo, and Alexandria.

Not all of these plants have the automatic controls. Many of the more recent plants use the upward flow, suspended-blanket method of settling, using suspended solids contact and sludge removal mechanisms. Also, in many of the later units, a control mechanism (Fig. 2) has been incorporated to maintain constant water levels in the other units when one is inoperative during washing. This is accomplished by controlling the opening of a butterfly valve in the raw-water line. When a unit is taken out of service, a pneumatic level control changes the air pressure on a valve positioner on the butterfly valve. This positioner

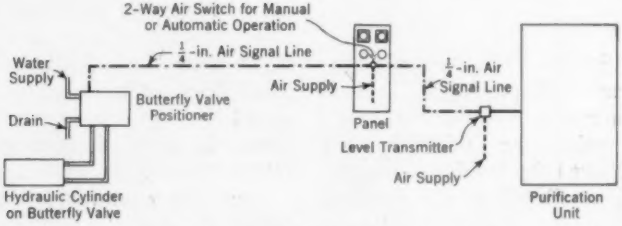

Fig. 2. Automatic Filter Level Control

controls the water supply to a cylinder on the butterfly valve, closing the valve sufficiently to equalize the flow into the units still in service and controlling the water levels within a 6-in. range.

There has been remarkably little trouble with the instrumentation and automatic controls. They are durable and require little maintenance.

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Procedure and Interpretation of Fire Flow Tests

George Tatnall

A paper presented on Oct. 16, 1956, at the Southwest Section Meeting, Little Rock, Ark., by George Tatnall, Asst. Chief Engr. National Board of Fire Underwriters, Chicago, Ill.

THE first essential in planning a set of fire flow tests is to have a complete and up-to-date map of the water distribution system. The map should preferably be in one piece so that proper analysis may be made of the entire system and it should be drawn using the symbols customarily used by the National Board of Fire Underwriters so that the strength and weaknesses of the system may be readily recognized by the engineer. The second essential in laying out tests is to have what is called, for want of a better name, the "structural map." This map is prepared early in the survey by a fire underwriter engineer, utilizing the latest available street map with a suitable base scale. On this map is entered information from the special insurance maps, first outlining the limits of the principal business district which has been selected for the city, and then, by the use of different colors, showing industrial and minor business districts, institutional groups, large apartments or other residential occupancies larger than two-family houses, and finally, one- and two-family residences. These data are supplemented from city land-use maps or, if maps are not available, by an actual drive through the outlying districts to locate every built-up area of the city as it exists at the time of the survey, and to record these areas with certain symbols.

Strategic Locations

For the purpose of classification, the *Standard Schedule for Grading Cities and Towns* (*1*) is based to a large extent on the protection to the principal business district of the city. The first tests which will be selected, therefore, are those which will cover that district. The schedule makes provisions for tests of the strongest and the weakest points in the business district, so that such locations must be determined. Quite frequently, it will not be evident which location is the strongest or the weakest, therefore, in a large district, two or three tests in each of these categories may be selected. Determination of the weakest test is not made arbitrarily by taking the weakest theoretical layout possible and concentrating entirely on small mains; but rather, the fire chief is consulted to determine which hydrants would actually be used in case of a near-conflagration fire at that location. From the structural map, the other important areas of higher fire flow demand will be easily determined, and tests will be spotted in important minor business sections, in the industrial and warehouse sections, at schools, colleges, hospitals or other institutions, and for any defined districts of multistory apartments. Tests are not necessarily planned at all such locations, but an attempt is made to

include the most important sections in all of the categories mentioned, unless it is obvious from the distribution system layout that ample quantities will be available. There is, for example, little need of making an actual test for a comparatively minor business district where two major arteries of the distribution system intersect. With these major tests outlined on the distribution system map, tests in purely residential districts are added in order to afford reasonably complete and uniform coverage of the entire city. Occasionally, for the purpose of proper system analysis, it is desirable to locate such tests directly on arterial feeders, but usually they are placed at the weaker points in the system gridiron, although not ordinarily to exploit such obvious weaknesses as dead ends. Recognition of this emphasis on the weaker test locations is made in the conclusions of board reports by commenting upon the better flows to be expected on or near the arterial feeders. When a report has previously been made by the National Board of Fire Underwriters, an attempt is made to have at least four or five tests at the same location and with the identical layout as the previous ones in order to obtain direct comparisons pointing to improvement or deterioration of the system during the interval between the reports.

Test Standards

Fire flow tests of the National Board of Fire Underwriters are made to determine the adequacy of supply under serious fire conditions. Some insurance organizations often test only one hydrant to determine the adequacy of supply under their specific rules for automatic sprinkler systems. Under serious fire conditions, naturally, more than one hydrant will be used; the board therefore lays out tests with groups of hydrants. A number of features must be considered in determining the size of the group and the specific locations of the residual and flowing pressure hydrants. In particular, the residual pressure hydrant must be so located that it is surrounded by flowing hydrants, or at least, so that it is away from any source of supply (pumping station or storage) in order that a true residual may be obtained.

The number of hydrants to be flowed at any given test is theoretically governed by the amount of fire flow to be required at that location, on the basis of not more than 1,000 gpm of required fire flow per hydrant. In practice, however, the number is usually limited by the size of the party which can be assembled for the tests and by the number of gages and pitot tubes the engineer can carry around in his test kit. Of equal importance is the strength of the system at the location under consideration and the amount of flow necessary to produce a sufficient drop between static * and residual pressures.

Preparations for Testing

As during a test fewer hydrants are flowed than would be under actual fire conditions, a compensation is made by flowing hydrants over an area larger than that being tested. At the same time, as a too great concentration of flowing hydrants can often have an adverse effect on test results, hydrants close to the one where residual pressure is being measured (across the street, for example, or in the same block) are not flowed. After the location of the fire flow test has been placed

* The term "static pressure" is really a misnomer for the pressure under the prevailing consumption demands.

on the distribution map, tests are numbered or lettered to indicate the order in which they will be run. An individual recording sheet is prepared for each, and on it is entered the location of the hydrant. At that time, it is usually desirable to make a preliminary estimate of the total amount of water which should be drawn. On sheets for flowing hydrants, the number and size of outlets to be used and the approximate pressure to be obtained are also noted to avoid too low a residual pressure in weak locations and, in essentially direct pressure systems, to avoid drawing too much water and overloading the pumps which may be in operation during the tests. The individual sheets are then bound in order of testing.

The matter of setting requirements for individual fire flow tests is a subject in itself and has already been covered in the JOURNAL (*2*).

Testing Procedure

It is customary to start the operation with one or two tests in outlying areas to get the test party operating smoothly.

Testing is theoretically simple. The party assembles at the first location, is given refresher instructions on the measurement of outlets to the nearest $\frac{1}{16}$ in., on the holding and reading of the pitot gage, and on the signals to be used. The flow men then move out to their respective hydrants, the gage to measure residual pressure is attached, and a static reading is taken. On a signal the hydrants are opened slowly and time is taken to allow the residual to become steady. On another signal simultaneous readings of residual and flow pressures are made. A last signal to close hydrants is given and each member of the party moves on to his next location. Ordinarily a 2–3-min period is ample to obtain a steady residual. Where the test is between the pumping station and the storage, it may be necessary to wait longer for the flow from the storage to reverse. Similarly, when there are slow-operating regulating valves or pumps which start or adjust automatically according to pressure at the station, additional time may be necessary.

Theoretically testing may be simple but in practice, however, innumerable difficulties are likely to take place. Street names are garbled in being tranferred to or from individual hydrant sheets; signaling may be hampered because of obstructions between hydrants; a passing sight may divert the attention of a tester and cause him to ignore signals; drivers of the trucks may lose their way; the electrical company may be splicing cables in an open manhole in front of the hydrant to be flushed; worn hydrant threads may threaten to blow off a gage attached to measure static pressure; stones in the stream may dislodge the pitot from a tester's hand or becomes wedged in the hydrant valve; the valve location book may have disappeared from its accustomed place in the truck; the hydrant valve itself may have been covered with blacktop and thus be impossible to find; and finally, an overenthusiastic reception of the shutoff signal may cause all hydrants to be closed at the same time with the result that a weak pipe section may burst. Fortunately, few of these difficulties occur in any one series of tests, and it is usually possible to make 25–30 tests, well spaced out over a city, in a day.

Initial Calculations

Before the test results can be analyzed, certain calculations must be made, and any corrections arising from

the individual characteristics of the system must be applied. Elevations of each location are obtained so that a water plane for the observed static pressures may be determined. Gage corrections noted in the calibration sheets carried in each test kit are applied. Discharge quantities for the appropriate outlet diameter and pitot pressure are determined from tables and, when the outlet is at least 4 in. in diameter, a deduction based on a 0.90 coefficient is made from the quantity of flow. This deduction is necessitated by the hole or hollow spot left between the stream and the lower lip of the outlet. The amount of the deduction will depend upon the height of this hole which has been observed by the man at the flow hydrant. The height will vary according to the flowing pressure and the size and design of the inner waterways of the individual hydrant. In extreme cases, deductions of as much as 25 per cent from the flow indicated in the tables may be necessary.

Pressure Drop Compensation

Analysis of tests continues to be held up until full details of operations at the pumping station or stations are obtained. Drops in pressure caused by the sudden draft are especially significant. Problems are likely to arise in connection with instructions given to operators of centrifugal pumps used without elevated storage. If an additional amount is pumped to supply the estimated amounts to be flowed on the larger-scale tests, the pumping station pressure will be more than normal between tests, and this increase will be reflected in the static pressure reading at the central hydrant. The station pressure will drop back to approximately normal during the flow period. On the other hand, if no additional pumps are operated, the station and static pressures will be normal before flowing, but the station pressure will drop materially during the flow period. In extreme cases, the drop in station pressure and the concurrent increase in delivery of centrifugal pumps may overload pump motors. This condition becomes more critical in the smaller cities and towns where the flow total may considerably exceed the prevailing consumption rate. Where there is manual control of fixed- or variable-speed motors, it is not feasible to attempt any adjustment during the test, as waiting for these adjustments to become effective and stabilized will block traffic too long and accumulate too much water on the streets. Pressure drops, therefore, must be accepted as normal for underwriter board tests. For an extended fire, however, adjustments could be made and usual station pressures restored. Drops in pressure are reflected in the residual pressure at the central hydrant, but as they are not the results of friction loss in mains, adjustments should be made in calculations if test results are to give a true measure of main capacity.

Pressure drops can often be read with sufficient accuracy from the station recording gage chart, except when the chart is small or covers an entire week instead of one day. It then becomes necessary to place someone at the pumping station to record pressure readings every 15 sec during the period of each test. Drops occurring in systems with some elevated storage facilities are only partly credited to the tests. The amount credited depends roughly on the proportion of water drawn from storage to that coming from the pumping station. In some instances, where tests are located close to elevated storage of limited capacity, it is obvious

that most of the flow is coming from the storage at a high rate, and notation must be made if the storage cannot maintain such rates for the standard periods of 4 to 10 hr, depending on the fire flow requirements.

Flows from individual hydrants are totaled and, with the corrected drop between static and residual readings, are placed on a Hazen-Williams hydraulic slide rule. The quantities for a drop of 20 psi, and at a residual pressure of 20 psi, are read off. Results are rounded off to the nearest 100 gal, as the board has never felt that this test method produced any closer accuracy. The accuracy, however, is sufficient, as the discharge of a fire stream may vary greatly while the stream still remains an effective one. The quantity for 20 psi drop will be discussed further in this article. The quantity at 20 psi residual is the end result of the test (the quantity available to compare with that which is required).

Timing of Tests

The consumption rate at the time of tests, especially in the principal business district, is determined as accurately as possible, making allowance for any increase or decrease in the level of elevated storage. Ideally, tests would be made, at least in the principal business district, when consumption was at the average rate for the maximum day, as this is the rate which the standards of board's grading schedule specify to be adequate. Survey work must be done throughout the year, however, and it is a coincidence when tests are made under ideal conditions of consumption. Calculations do take this into account, so that no city should feel abused if tests are made, as they occasionally are, under almost absolute peak hour consumption demands. When consumption varies materially (either less than or particularly more than the average rate for the maximum day), special mention is made in the report as to the effect of this on the tabulated test results.

City Initiative

Many cities carry out their own fire flow tests whenever necessary or desirable, rather than waiting for the next underwriter's survey. A crew may readily be trained to make these tests, and the necessary equipment is not too expensive. If pitot tubes are not available, reasonably accurate results may be obtained for flowing pressures by attaching an ordinary gage to the unused $2\frac{1}{2}$-in. outlet when only one such outlet is flowed. Further hints and test procedures are given in a National Board of Fire Underwriters bulletin (*3*). A special tabulation permitting the calculation of quantities available at 20 psi residual without a hydraulic slide rule has also been issued.* It is particularly desirable for a city to make tests before and after the installation of reinforcing mains under comparable consumption conditions. Resulting figures may be used to convince skeptical supervising officials of the desirability of the changes.

Test Analysis

Test data are now analyzed in the hope of discovering facts which may be of value. Hydrant flow notations and extent of hydrant opening are studied. A wide-open hydrant delivering 3–5 psi flowing pressure with a 30–35-psi residual a block away indicates a closed valve or other obstruction between the two. By the same token, in a system where hydrant discharge normally

* Available on request from the National Board of Fire Underwriters, 85 John Street, New York 38, N.Y.

clears after flushing the branch, a notation of persistent dirty flow often indicates the presence of a closed valve somewhere nearby. Careful comparison is also made with the tests of previous surveys at the same location, with an allowance, if necessary, for any change in static pressure conditions. The quantities obtained from the slide rule for a drop of 20 psi are noted on the distribution system map where the tests were originally outlined. These calculations eliminate the influence of varying elevations and permit an accurate comparison of one test with another on the basis of the mains as shown on the flat map; the largest amounts of flow, therefore, should be in the large mains, close to the pumping station or storages, with progressively smaller amounts in the arteries, and with still further orderly decreases for tests on the gridiron, depending on the distance from the arteries. Any test which shows a marked variation from this consistent pattern is noted and valves in the vicinity are included on the board's inspection list. When a closed valve or other obstruction is found, tests are rerun or appropriate notation of the effect is made in the report.

Inconsistencies do not always spring from a closed valve. Sometimes, the variation may be caused by the interior condition of mains, while at other times, there seems to be no logical explanation based on the laws of hydraulics. The board seldom has time to conduct more detailed investigation, so that it strongly urges that cities make such investigations. Occasionally, obstructions in mains are spotted after further investigation. If the available quantity remains deficient, a recommendation is made later in the board's report for the installation of a main or mains to overcome this condition.

Summary

The laying out of fire flow tests is logically linked to obtaining information which will protect areas of high life-hazard and high dollar value. Other tests are needed to give a uniform coverage of the city. Advance planning and preparation transform the actual conduct of tests into a more-or-less routine operation. Calculation of the results also is somewhat routine, but care must be taken to make correction for system conditions which might distort the measure of main capacity. Careful analysis of the results often discloses closed valves or other conditions, which, when remedied, will improve the system without particular expense. In any case, such analysis gives a sound basis for the recommending of additional mains to provide proper fire protection throughout the city.

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Investigation and Handling of Water Quality Complaints

William M. Wallace and Albert M. Shannon

A paper presented on Sep. 14, 1956, at the Michigan Section Meeting, Kalamazoo, Mich., by William M. Wallace, Supt. of Filtration & Sewage Treatment, and Albert M. Shannon, Supervisor of Filtration, both of the Dept. of Water Supply, Detroit, Mich.

THE whole subject of customer complaints, including those of water quality, low pressures, and high bills, falls under the general heading of public relations. Many small water plant superintendents probably feel that public relations are not their concern. They are wrong! Willingly or unwillingly, every water works manager and superintendent is conducting a public relations program to obtain the good will and confidence of his customers. Every employee coming in contact with the public can affect the program. In fact, every contact between the public and the department offers, if properly handled, an opportunity to increase the public's respect for the company.

It is well to remember that the public judges utilities by their efficiency and businesslike manner. Inefficiency accompanied by ill will will raise great criticism; good will and efficiency, on the other hand, will make for a tolerant and understanding public. The public is interested primarily in receiving a good quality water with good service at a reasonable cost, so that good quality with poor service, or poor quality with good service will win no friends and influence no one, though the water be delivered free.

Water, which is usually safe and palatable, may occasionally suffer in quality. An almost unproportionate volume of complaints will be registered for these small failures. A small percentage of these complaints will be the result of taste and odor in the supply, but by far the larger percentage will be of foreign matter suspended in the water. The foreign matter may be rust particles, which will spot laundry; fine sand or silt, which is the turbidity that may come through the sand filters and settle out together with alum floc; or air in the water, formed by air coming out of solution because of increased water temperatures in the home and the lowering of pressure when drawing the water. Most of the foreign matter will remain in the mains undisturbed for years without causing any difficulties. Then one day, a fire in the neighborhood, an improperly closed fire hydrant, a reversal of flow, a main break, an abnormal flow, or a failure to adhere to schedule when flushing dead ends may cause the resuspension of the turbidity. Many of these difficulties are beyond the control of the water department, yet the department is held responsible by the consuming public. To maintain the public's good will, therefore, it is important that customer complaints be answered as soon as possible to the satisfaction of the consumer.

Public Relations Personnel

Irrespective of the size of the utility, one person should be in charge of receiving the complaints. The same person should answer in small utilities, although in large ones, it might be more efficient for someone else to answer. The selection of the person or persons to receive and answer complaints will contribute largely to the success of a public relations program. The employee should be pleasant, tactful, friendly, a good listener, and possess the ability to hold his temper regardless of the amount of provocation. It should be impressed on this employee that the customer did not invent an excuse to complain and may feel that his grievance is unique as well as serious. Most complaints are made in good faith, and the customer is entitled to a complete investigation and report.

Receipt of Complaints

After the complaint is received, it should be investigated as soon as possible. Prompt response alone will do a great deal to impress the customer that the utility is interested and wants to correct any difficulties. In addition to being very pleasant and polite, the investigator should not interrupt the customer while he is describing his complaint, regardless of the extravagance of the claim being made. Having unloaded his troubles, the consumer usually calms down and is ready to listen. The investigator should then seize the opportunity to explain the probable cause of the trouble.

Cause for complaint has often disappeared by the time the investigator has arrived at the home of the consumer. If it continues, however, the employee should flush the main. The employee should also carry a residual chlorine measuring kit and he should determine the residual in the presence of the customer. After reading the residual, he can safely assure the customer that the water is safe and, at the same time, explain the cause of the trouble. He should also make every effort to convince the consumer that the water is treated properly by explaining the precautions that are taken such as the laboratory tests continuously run to insure a safe and palatable water. If the department is at fault, it should be so admitted, and every effort should be made to correct the trouble promptly. If the condition is beyond the control of the utility, or is harmless and cannot be readily remedied, the customer should be told. In every case, regardless of the nature of the complaint, samples for physical and bacteriological tests should be collected. The consumer should also be told that he will be informed of the results of these tests as soon as possible. He should, of course, be asked to notify the department if there is a recurrence of the difficulty.

The following steps will go a long way to please and satisfy customers, thus building good will for the water department: [1] the measurement of the chlorine residual and the assurance that the water is safe because it does carry a residual, together with a straight-forward explanation and prompt correction of the cause of the difficulty whenever possible; [2] the collection and analysis of samples; and [3] the notification of the test results.

Detroit Experience

Prior to 1940, there was no system for handling customer complaints in the Detroit Department of Water Supply. Complaints were received by the laboratories, the service yards, the engineering division, and the telephone op-

erators in the main office; in fact, anyone in the department might receive a customer complaint. As no single person was responsible for receiving complaints, considerable confusion existed as to the proper method of handling them and, as a result, customers were dissatisfied.

In May 1940, a Customers Service Bureau was organized in the downtown office of the Detroit Department of Water Supply. Its purpose was to centralize all customer orders, inquiries, and complaints under one head. Before starting this new bureau, an employee in-service training program was introduced. The training course was developed and conducted by an instructor in the School of Public Affairs of Wayne University assisted by several staff members of the Department of Water Supply. This program was financed largely by the federal government under provisions of the George-Dean Act as administered by the State Board of Control for Vocational Education through Wayne University. The course consisted of study from a textbook specially prepared to cover the water department's customer service problems, class sessions in which the conference method was used, and frequent tests and training on the job.

The employee training has continued, although it has been limited to new employees in the bureau and in coaching individual clerks on particular transactions. Occasionally, group sessions are held for instructions on new departmental procedures and regulations. This new bureau was divided into two parts: the telephone and records section, and the service counter section. The latter, serving those customers who come in person to the office, has employees selected largely for their suitable personalities. The formation of the Customers Service Bureau and the centralizing of all customer inquiries, requests, and complaints has been successful for it has prompted a definite improvement in the service rendered to the consumers and a resulting improvement in customer relations and good will.

During normal office hours, all telephone calls pertaining to complaints are taken by the telephone section which relays the messages to a designated person for investigation. Calls which are received at the main office after regular office hours and on Saturdays and Sundays, are transferred by direct line to a dispatcher at the central yard, who relays the complaint for investigation. A record is kept of all complaints received, showing the name, address, telephone number, ledger number, nature of the complaint, time and date it was received, time and date it was referred, and the name of the employee receiving the complaint for investigation. A copy of this record is sent to the supervisor in charge of the investigation.

Since its inception to the present time, the procedures followed by the Customers Service Bureau have been essentially the same, with some minor improvements from time to time. When a complaint of rusty or turbid water, or a complaint of a bad taste and odor is received, the customer is asked to save a sample for the investigator when he calls. In the case of turbid water, the customer is asked to let the water run in the laundry tub, because experience has shown that unless there is a major disurbance in the main, it will clear up in a short time. After investigating, confirming the findings, and stating that the water meets USPHS standards for a safe drinking water, the Customers Service

Bureau calls the consumer to learn whether there has been a recurrence of the difficulty and whether the customer is satisfied. If he is not, the investigation continues until the difficulty is corrected to the satisfaction of the customer and the water department, or until it is found that there is no reason for the complaint.

Before 1946, all complaints of tastes, odors, sickness, and the unusual or miscellaneous ones were referred to the filtration division for investigation. These were answered by a member of the laboratory staff. The complaints of turbid or rusty water were referred to the maintenance and construction division, where a member of one of the leak or flushing crews usually investigated the complaints. The procedure was to take a sample of water from the house, flush the closest hydrant, and take another sample. No bacteriological sample was taken and little or no explanation was given as to the cause of the main disturbance. While these men were excellent workmen and did remedy the trouble, they were not very adept at public relations. As a result, customers were often dissatisfied, and thus another visit to pacify them was required. There was also considerable duplication in that the customer called both the Customers Service Bureau and the laboratory.

The Customers Service Bureau was so successful in dealing with customers that it was decided to concentrate all water quality complaints in one division, and to assign investigation duties to one man furnished with an automobile. In 1946, this job was given to the filtration division, and a man with a suitable personality was selected and trained for the job. While a technical background may be advantageous, it is not necessary because the desirable personal characteristics (equanimity, tactfulness, friendliness, neat appearance, and the ability to talk to customers in a convincing manner) are more important in building good will. The more difficult complaints which require technical knowledge are answered by one of the sanitary chemists. The filtration division was also given the job of sending a letter to every customer who complained about the water quality, giving them a report of the investigation.

Sources of Complaints

From Jul. 1, 1955 to Jul. 1, 1956, the filtration division investigated and reported on 594 complaints. In the 1954–1955 fiscal year, 537 complaints were received and in 1953–1954, 856. Of the 594 complaints received in 1955–1956 512 resulted from turbid water, and 78 from tastes or odors. Four complaints of illness were received, all of which were found to be unjustified. A breakdown of the causes of the 512 turbid water complaints is as follows: hydrant operation, 375; abnormal flow, 32; main breaks, 15; local conditions, 62; and cause unknown, 28.

Hydrant operation, chiefly the improper handling of hydrants, was responsible for the majority of the turbid water complaints. The proper handling of the hydrant (opening up the valve slowly and closing it down slowly after the water is clear) will not cause main disturbance. The rapid closing of the hydrant valve, however, will cause a surge in the main which will resuspend the silt present. It has been Detroit experience that other city departments and contractors are the chief offenders in spite of repeated warnings.

The complaints caused by abnormal flow or reversal of flow are the result of putting reservoirs and booster sta-

tions in service at the beginning of the heavy-demand season.

The complaints due to local conditions are usually of air in the water, or rusty water which actually came from a defective hot-water tank or other domestic appliance. This can usually be proved to the customer's satisfaction by determining the iron content of the hot and cold water.

Turbidity complaints, where actual sediment is present in the water, can be corrected by flushing the main. If the condition is due to a dead end, the main is flushed and then placed on a regular flushing schedule determined by the time it takes to form rusty water again.

The 78 complaints of objectional tastes or odors that were investigated and reported, did not include 410 complaints of medicinal taste in the water which occurred in a period of three days when a waste phenol reduction plant 60 miles above intake on the St. Clair River failed. A slight medicinal taste was present in the effluent from one treatment plant where contact time and chlorination facilities failed to oxidize the phenol adequately. These complaints were spotchecked by an investigator and an explanation of the cause of the difficulty was given to most customers over the telephone by the Customers Service Bureau. An explanation by the general manager of the water board was published in a newspaper.

Taste and odor complaints investigated stemmed from: new hot-water heaters, 20; local plumbing conditions, 24; plastic garden hose, 7; hose on automatic washing machines, 18; leaking carbonic gas, 3; refrigerated drinking fountains, 3; and cause unknown, 3. The tastes or odors caused by the installation of new hot-water heaters, automatic washing machines, and changes in the plumbing are due to the use of pipe compounds which form taste-producing substances with the chlorine in the water. Continued use and flushing will gradually wear off the excess pipe compound inside the pipe and the taste in the water will disappear. The plastic garden hose and the synthetic rubber hose used in the installation of automatic washing machines can react with the chlorine in the water to form taste-producing compounds if there is sufficient contact time. These tastes can enter the plumbing system of the house if the hoses are not valved off when not in use. The position of these hoses in the plumbing system determines whether or not tastes will back up or be swept into the house system. A hose at the extreme end will cause no trouble. One near the beginning, however, can cause tastes in the water. After the hoses have been in use over a period of time, they cause no difficulties. A plastic hose shutoff at the nozzle and left exposed to the sun will continue to form taste-producing compounds. A plastic hose used for filling the storage tanks on boats at a yacht club had to be replaced with a rubber hose because of the taste difficulties. Failure of check valves in carbonation systems in soda fountains can cause the water supply of buildings to be slightly carbonated. Refrigerated drinking fountains can impart either a musty or sweetish taste to the water. The musty taste can be corrected by cleaning the coils in the fountain, and a sweetish taste is an indication that the refrigerant is leaking into the water.

Summary

The proper processing of all customer complaints (not only those of

water quality), offers an excellent opportunity to build good will and thus aid the public relations program of a water utility.

The Detroit Department of Water Supply has successfully handled customer complaints, inquiries, and orders by: establishing a Customers Service Bureau, staffed with properly trained, suitable personnel under one head; by delegating the responsibility of investigating and reporting on all customer complaints pertaining to water quality to one division; and by providing a trained investigator.

The procedure used is: to investigate every complaint received as promptly as possible; to flush the main if the condition warrants it; to determine the residual chlorine in the home and, from the results, assure the consumer that the water is safe; to provide a straightforward explanation and prompt correction of the difficulty whenever possible; to collect and analyze physical and bacteriological samples; to send a letter to the customer as soon as possible, giving the results of the investigation and laboratory tests; to check by telephone in order to learn if there has been a recurrence of the difficulty and if the customer was satisfied; and to reinvestigate until the consumer is satisfied or there is no more cause for complaint.

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Construction and Public Relations

Gerald W. Jones

A paper presented on Oct. 24, 1956, at the California Section Meeting, San Diego, Calif., by Gerald W. Jones, Exec. Staff Engr., Water System, Dept. of Water & Power, Los Angeles, Calif.

IT has only been during the last few years that water utilities have become conscious of public relations. For years, pipes were buried deep in the ground, and pumps and treatment plants were placed down by the river where they were out of sight and out of mind. Meter readers fought off the customer's dog and his owner's sense of proprietorship of the meter. Bills were rendered with all the tact of a summons to criminal court. The language on the face of bills set out clearly the time limitation for payment and stated in terse terms the penalties for nonpayment.

The improvement in public relations started with customer relationship and gradually spread throughout the water business, including major construction.

Sincerity and Honesty

Public relations in construction, like good public relations of any kind, begins with an attitude—the sincere desire to perform work in a manner which will cause the least inconvenience without actually adding to costs. A sincere attitude will be reflected in planning, design, specifications, timing, and very obviously, in physical performance.

Another important aspect in the development of a public relations program is the assistance of good communications. Good intentions and careful planning will eventually be revealed to those most affected, but perhaps only after many misunderstandings.

A number of years ago, for example, the water system of the Los Angeles Department of Water and Power found it necessary to rehabilitate a large water tank. The tank, which was 80 ft in diameter and 50 ft high, was situated in a residential community. At the time of construction, the location was remote, but residential encroachment was anticipated and landscaping plans were initiated, completely hiding the tank from view. Large trees grew around it in profusion and, in addition, poultry netting was draped from the top of the tank to which Australian pea vine clung, forming a rank green shielding growth. In time, the vine supports failed, permitting the vegetation to lie directly against the tank, thus destroying the paint and corroding the metal. Construction plans required the removal of vines, sandblasting and painting of the tank, restoration of vine supports, and roofing of the reservoir.

The work was planned carefully and scheduled so as to produce a minimum of noise, dirt, and confusion. The sharing of these plans with the immediate neighbors was considered, but finally discarded because of the belief that apprehensive persons might initiate adverse petitions and thus delay or make the work doubly difficult.

If the fear of resistance existed prior to the commencement of the work, it was nothing in comparison with what happened when the neighbors awoke

one morning to find an 80-ft tank next door—a tank most of them did not know existed.

Claims and complaints poured in; respiratory troubles, allegedly caused by dampness, appeared all over the neighborhood; thousands of dollars in property depreciation claims flowered, and general unhappiness prevailed. The work was completed with dispatch in an orderly fashion and the feathers gradually settled, but the public relations were not pleasant—merely intimate.

A contrast to the previous example was provided by the construction of a 51-in. concrete pipeline designed to lie in a narrow residential street with many apartment houses. Fearing the worst and having little other recourse, it was decided to inform residents living along the route of the plans, work methods, timing, and so on. The inconveniences were quickly admitted, but at the same time residents were reminded that the pipeline represented the progress—a reason for extending understanding support to the project. To the amazement and gratification of the department, complete cooperation was received. Only two complaints were received. Followed up with personal calls, and upon full explanation, the complaints were withdrawn.

Some mistakes in communications were made. Notices were addressed, for example, to "occupant" instead of looking up the name at each address; they were then slipped under doors instead of being delivered through the US mails. In spite of all this, the result was splendid.

This single example illustrates clearly the need to "confide" to the people affected by construction work. Personal letters, newspaper space, and talks before local civic clubs, chambers of commerce, and schools are excellent instruments of communication.

The Positive Approach

Very few people can resist the attraction of a job of major proportions; every man is, by instinct, a builder, and his ability to drive a nail or saw a board has no bearing on that instinct to build. Combined with this need for creativity is the inner feeling of good citizenship giving rise to the desire to promote the welfare of one's neighborhood, city, state, or country. Americans are reasonably mature people, willing to bear considerable inconvenience for the common good. These characteristics are a perfect medium for good public relations in construction. Unusual construction problems and their solutions should be pointed out; general methods should be outlined; and, above all, the benefits which will accrue to the immediate vicinity and the community in general should be called to the attention of all, for these benefits will endure long after temporary inconvenience is over. In other words, one should take a positive, constructive approach.

In Inglewood, Calif., a 66-in. reinforced concrete pipeline was being installed through the business district some 10 years ago. The administrative officer of the city and the author were summoned to a meeting of the North Inglewood Chamber of Commerce, where unhappy businessmen, faced with a blocked thoroughfare past their establishments, confronted them. A few unkind words were recorded regarding the author, his employer, the contractor, and the legislative branch of the city for permitting such havoc. The administrative officer took this calmly and quietly suggested a more constructive approach. He arranged

for a full page spread in the local paper, calling attention to the giant project under way, where it was located, what it was accomplishing for Southern California and invited everyone to shop in North Inglewood and watch this wonderful thing in progress. The merchants provided off-street parking and enjoyed the greatest volume of business they had ever had. The contractor had to hire guards to keep people out of the ditch and from under the hoists and draglines, but the work proceeded before an admiring audience and gratified businessmen.

In contrast to this, a large business concern in the western part of the city, which runs a daily advertising column in the city's largest daily newspaper, used the column to describe the dirt, the noise, the blocked streets, the lack of parking space when a large pipe was being installed in their street. In spite of the fact that all driveways were bridged and maximum parking space was provided, business dropped all along the street causing suffering to many innocent businesses. The constructors were able to counteract the damage somewhat by local paper publicity, but the persistent negative approach of the daily column was a destructive force difficult to combat, and a business house that considered itself a martyr and standard bearer for all the business along the street not only cut its own volume to ribbons, but also that of its neighbors whom it was trying to defend.

These two examples illustrate the value of getting the public to identify itself with the job in a constructive way. Another example, a little more pointed, may be of interest.

In 1948, a 51-in. pipe was being installed in a right of way in the San Fernando Valley. The easement had been obtained many years previously, and neighboring property owners had encroached upon it. In one particular location, an elderly gentleman had planted a peach orchard and had constructed a chicken pen on the right of way. As the time approached to commence the job, the man let it be known that no one was going to dig up his orchard. He had a double-barreled shotgun and was prepared to use it. Adjacent to his property was a branch line of the Southern Pacific Railroad. Construction agreements required that the tracks be crossed by a thimble, jacked in place without disturbing the subgrade of the tracks. This became one of the first jobs under the contract. The contractor's superintendent, although aware of the old man's hostility, asked him to help by guarding the excavation during nonworking hours to prevent school children from getting hurt. The old man was delighted.

A few days later while checking the progress, the author discovered that the men had "daylighted" the trench into the right of way approximately 5–6 ft. The superintendent had been especially cautioned against this, and the author complained about it. The erstwhile shotgun bearer defended the men and the work with such vehemence that the author quickly retreated. When the time came to cross his property, the owner helped clear the right of way. He had become identified with the job constructively.

Human Fears

Public relations in construction jobs do not deal exclusively with easing discomfort or inconveniences. Good construction design also relates directly to the public. Strange structures may often cause fear in timid or apprehensive people. Covering or camouflaging

these will help mitigate the fears. The difficulty is to recognize the fear beneath complaints of aesthetic disapproval. People will seldom admit fear because it is an emotion which can neither be supported by the mind nor sustained by the nervous system.

An automatic air valve adequate to handle the requirements of a large gravity pipeline of fluctuating discharge is a thing of beauty to a water works man because it means a minimum of concern in line operation. To a layman, however, it is as big as a trash barrel and a threatening, mysterious device. Economics dictates that the airline from pipe to valve be as short as possible and still maintain an upward gradient. The valve is not normally installed in driveways and entry walks; otherwise, it is set as close as possible to the high point of the line. At the same time, some care should be taken of blending the valve into the environment, by painting it, hiding it in shrubbery, and so on. Failure to harmonize equipment into the landscape was the reason of complaint in the following example:

The Santa Monica Mountains area is traversed by long, winding contour roads with limited access and few cross streets. Tie lines in the water system grid must be installed in easements, some of which are steep enough to make a goat hesitate. The Los Angeles water system recently obtained such an easement along a lot boundary and proceeded to install the tie line. The lower end of the 8-in. pipe traversed a 1:1 cut dropping approximately 45–50 ft to roadway level. The cut was in solid rock and the design contemplated the installation of 8-in. pipe in a single surface span between anchor blocks at top and bottom. The construction forces did an excellent job of installing, and the pipe was painted to blend with the rock of the embankment. Almost immediately, complaints of alleged ugliness and consequent depreciation of property were received from people living at the bottom of the easement area. The department was at a loss to understand this because the raw cut rock slope which the pipe traversed had been rather ugly, and the symmetry of the pipe installation improved it, if anything.

It was finally discovered, by standing in the neighbor's driveway, that the pipeline appeared to emerge from the bank and plunge down 50 ft directly at the house. It was the fear complex and not lack of beauty that had caused the trouble.

Summary

Good public relations in construction leads to more economical jobs and to pleasant work. It takes a little time and trouble, but pays off handsomely. Design and administrative planning cost money, but these costs can be small compared to expenses which ensue when construction itself is delayed or stopped by public resistance. Public relations also adds to the general good feeling toward the utility, and can mean all the difference in the world when it is necessary to raise rates, issue bonds, or ask for other support.

The rules of good public relations in construction are simple—one should approach the job with a sincere desire to be as thoughtful of all concerned as possible; take the people into one's confidence; identify their interest with the job; and follow through.

Automatic Chlorination Control by Continuous Remote Residual Determination

William Bruce Murray

A paper presented on Oct. 26, 1956, at the California Section Meeting, San Diego, Calif., by William Bruce Murray, Asst. Civ. Engr., Long Beach Water Dept., Long Beach, Calif.

IN many instances, water treatment plants which practice superchlorination have difficulty in maintaining a uniform postchlorination residual in the plant effluent. Automatic regulation of the finished water residual to a desired value may represent a possible solution to the problem. Variations in residual which result with a fixed superchlorination dosage usually derive from a changing chlorine demand in the plant influent or from weather or seasonal variations in sunlight. A typical 24-hr plot of residuals under the above conditions will generally contain one or more maximum and minimum peaks of moderate slope. Figure 1 illustrates the effect of daylight on a water superchlorinated to a residual of 14 ppm and then retained for approximately a day in a large outdoor basin.

Floating Control System

A constant postchlorination dosage applied to the effluent of a treatment plant operating under the above conditions generally results in a non-uniform chlorine residual. The automatic control device described here corrects this condition and holds the chlorine residual to a pre-selected value by a process known as a "floating control system." In this system, the activation device or control element causes the chlorine feeder to operate at a compensating rate as long as the chlorine residual deviates from the desired value. A typical floating control system in chlorination control employs a motor-operated chlorine feeder regulating the flow of chlorine to the plant effluent. The variable conversion or detecting element translates the instantaneous value of the chlorine residual into the necessary force to control the chlorine feeder. If the residual drops below a selected point, the circuit to the motor-operated chlorine feeder closes and the rate of chlorine feed to the plant effluent is increased. The motor continues to run, increasing the rate of chlorine feed, until the chlorine residual reaches the value which will cause the motor to stop. Conversely, when the chlorine residual rises above the selected value, the rate of chlorine feed decreases until the residual has fallen to its desired value.

The speed of the motor (in this example) is established so that the rate of chlorine feed will not run its entire scale before the chlorine residual has become stabilized. In other words, a very slow-operating unit is used where transfer lags of considerable size exist in the system and where hunting (overshooting the dead zone) is a possibility.

In general, this type of floating control system employs a dead zone in order to prevent continual excitement

of the control element. This dead zone is the region where insignificant changes in chlorine residual will not produce action. The dead zone may be a fraction of a unit wide or several units wide

Detecting and Correcting Systems

The flow diagram of Fig. 3 shows, located at fixed distances along the conduit, a detecting device and a correcting

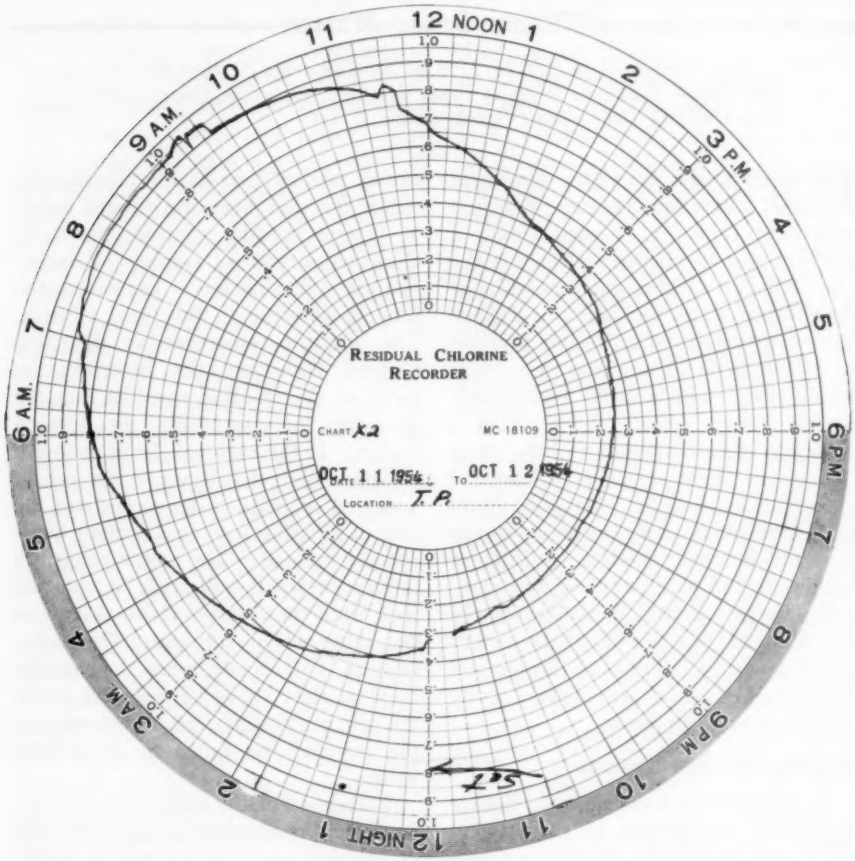

Fig. 1. Typical Residual Chlorine Chart Showing Effect of Superchlorination on Plant Effluent

Chart is from the residual chlorine recorder at the treatment plant at Long Beach, Calif.

depending upon the allowable variation in the process and other factors. Figure 2 shows the general characteristics of the floating type of controller in chlorine regulation.

device. The detecting device evaluates the chlorine residual present in the effluent—including that applied by the correcting device. The correcting device, which represents the motor-

operated chlorine feeder, either increases or decreases its setting as dictated by the detecting device.

Cell Block Assembly

A diagram of the cell block assembly of the detecting element is shown in Fig. 4. It consists of a clear block of plastic divided into two cylindrical compartments together with an electrode unit which is interconnected between the compartments by means of flexible plastic tubing.* A 300 ml per minute sample of the plant effluent is jetted from one compartment to the second where it is chemically adjusted before it is passed through the electrode unit to the first compartment and, eventually, the overflow or waste pipe.

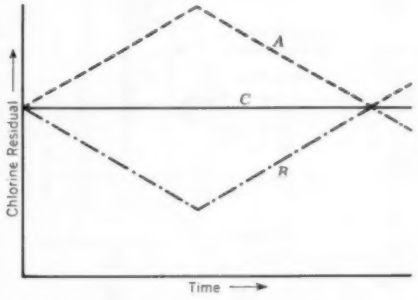

Fig. 2. General Characteristics of the Floating Type of Control

Curve A *represents the change in chlorine residual per increment of time in which it is desired to correct to a designated value (Curve* C*). Curve* B *is a reciprocal of* A*; its value, in terms of chlorine residual, is proportional to the rate of chlorine feed to the plant effluent.*

* The tubing used was made of Tygon, a synthetic rubber-like product of US Stoneware Co., Tallmadge, Ohio.

Electrode Assembly

The electrode assembly establishes a flow of current between two dissimilar metals (copper and platinum) which is directly proportional to the concentration of chlorine in the water sample. This unit is constructed in such a manner that the copper electrode serves as the water sample conduit through the main body of the electrode assembly. An electrical potential is established in the presence of the sample with a platinum wire which passes through the axis of the copper conduit. Electrical contact is made to each pole through set screws on either side of the main body. A small amount of grit is added to the incoming sample to keep the surface of the electrodes polished and to prevent polarization.

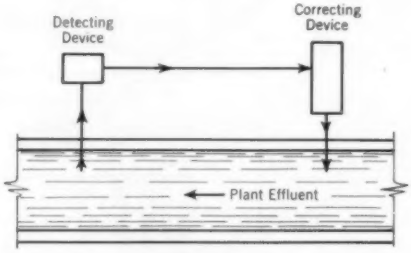

Fig. 3. Flow Diagram of a Floating Control System

The detecting device measures the chlorine residual in the effluent, including that applied by the correcting device.

Chemical Injection System

Acetic acid and sodium acetate are added to the incoming water sample in order to make certain chemical changes before the sample enters the electrode assembly. This solution is added to the

water sample by a constant-discharge gravity feed system which consists of a reservoir, an atmospheric discharge tube, a reservoir inlet, and a reservoir discharge from which the solution flows and the constant head overflow well located on the second compartment of the cell block assembly. Minute solution flows of 0.1 ml per minute or less can be achieved by the adjustment of

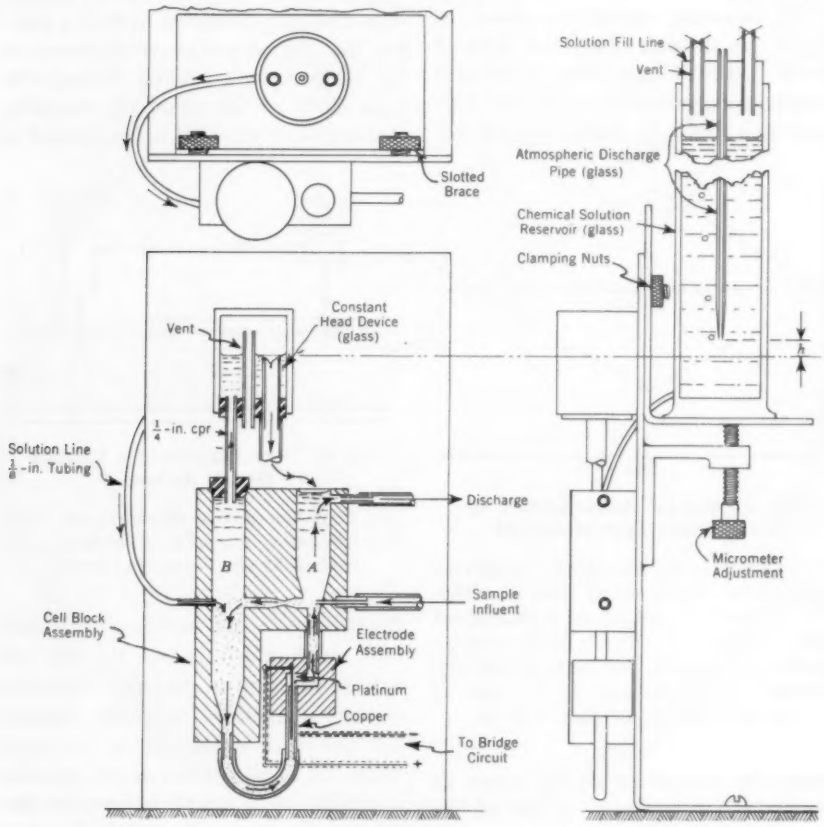

Fig. 4. Diagram of the Cell Block Assembly of the Detecting Mechanism

The sample of the plant effluent is chemically adjusted in Compartment B *before it is passed through the electrode unit and back to Compartment* A.

from the reservoir to the cell block assembly. The effective head producing this discharge is between the tip of the submerged atmospheric discharge tube and the micrometer setting which either raises or lowers the reservoir in relation to the fixed head of the cell block assembly.

Electrical System

The electrical output of the electrode assembly is approximately 20 μa per 1 ppm of chlorine residual. This output is made to do useful work by balancing it against a bridge circuit and by determining the balance across a double-contact meter relay (Fig. 5). A 2,000-ohm potentiometer functions as a range-adjusting potentiometer and a 0.5 megohm potentiometer serves as a zero adjustment by providing a bucking current against the electrode assembly input. A 10-turn, 200-ohm, variable slidewire potentiometer is used to set the control point in units of chlorine residual. The bridge circuit balance is obtained across the meter relay which has a pair of adjustable contacts on either side of electrical zero. Once the control point is set, a rise and fall of chlorine residual in the cell block assembly samples moves the meter needle to one side or the other of electrical zero, controlling closure of the relay contacts and, eventually, the rate of chlorine feed. A very important aspect of this type of control is the sensitivity adjustment. Assuming the points of detection and correction are at a fixed distance along the effluent conduit (the shortest distance commensurate with a good mix is desirable), the sensitivity

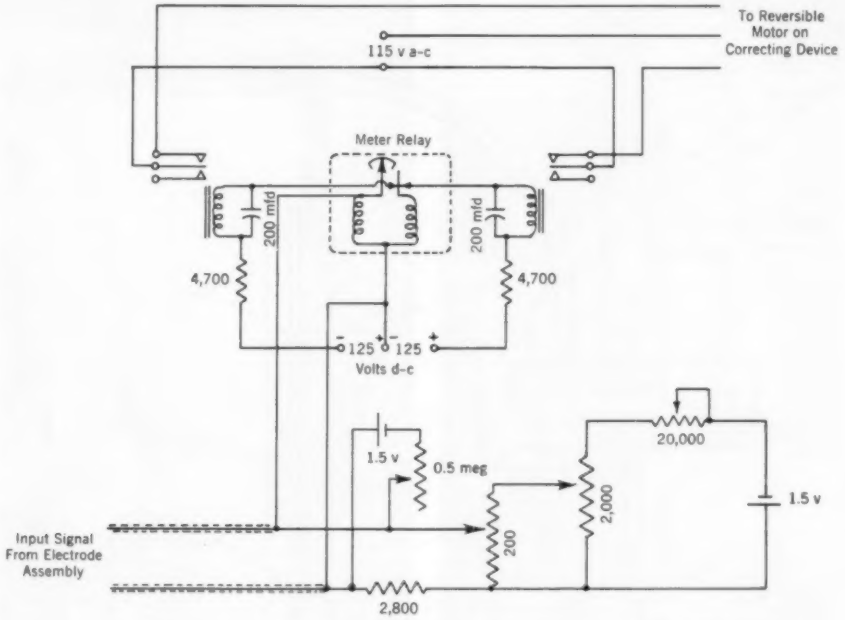

Fig. 5. Diagram of the Electrical System of the Detecting Mechanism

The 2,000-ohm resistor serves as a range-adjusting potentiometer, the 0.5-ohm potentiometer is the zero adjustment, and the 200-ohm potentiometer is used for setting the control point in units of chlorine residual.

of control can be adjusted by varying the space between the adjustable meter contacts or by changing the rate of "cam" make-and-break on the relay tacts which are a part of the meter relay and the detecting system can be in one of three states of operation while affecting the rate of chlorine feed:

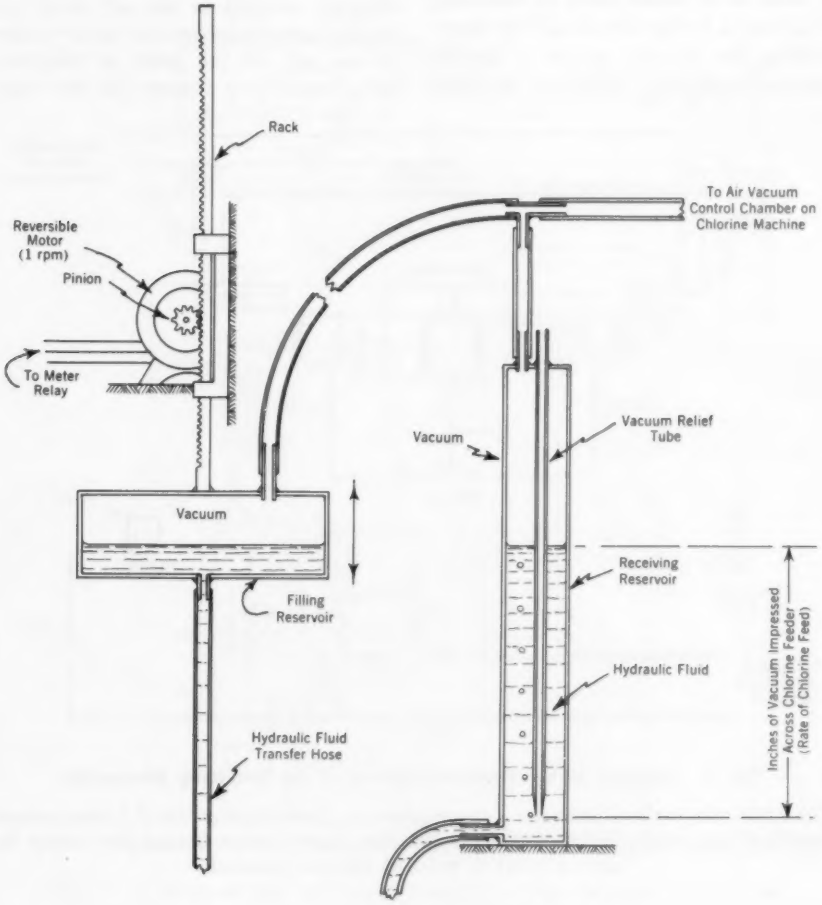

Fig. 6. Diagram of the Correcting Mechanism

power supply motor control. This sensitivity control is made by trial and error. It is desirable to have fast correction response, but the disadvantage of hunting must not be overlooked in making an adjustment. The relay con-

1. The bridge can be at a point of balance where no residual correction is required. In this state, the needle is operating in the meter dead zone, the motor is inoperative, and the rate of chlorine feed remains unchanged.

2. The bridge can be at a point of electrical unbalance in which the residual in the electrode assembly is *lower* than that set at the control point, with the result that the meter relay energizes the motor and the rate of chlorine feed is increased.

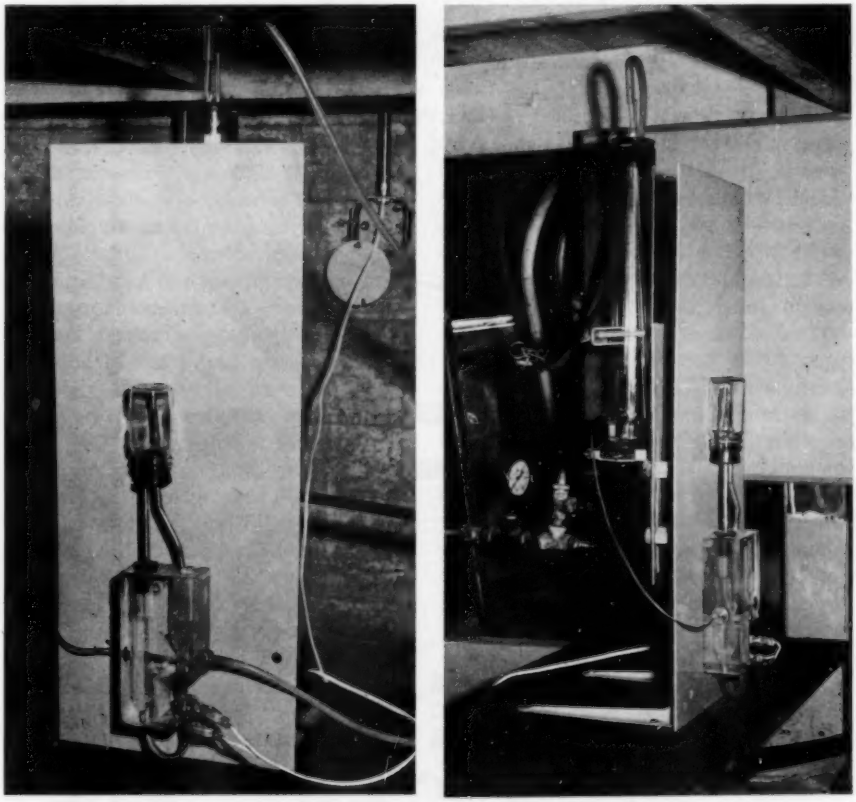

Fig. 7. Two Views of the Electrode and Chemical Solution Reservoir System

3. The bridge can be at the point of electrical imbalance in which the residual in the electrode assembly is *greater* than that of the control point, with the result that the motor operates in a reverse direction and decreases the rate of chlorine feed.

Correcting Device

The correcting device diagrammed in Fig. 6 is composed essentially of a vacuum type chlorine feeder,* a reversible motor-driven rack and pinion, a filling and receiving reservoir, hydraulic fluid, and several lengths of rubber hose. A vacuum type chlorine feeder operates on a principle of vacuum control in which the maximum feed is equivalent to 12 in. of water. Varying

* Such as the Model A-421 manufactured by Wallace & Tiernan Inc., Belleville, N.J.

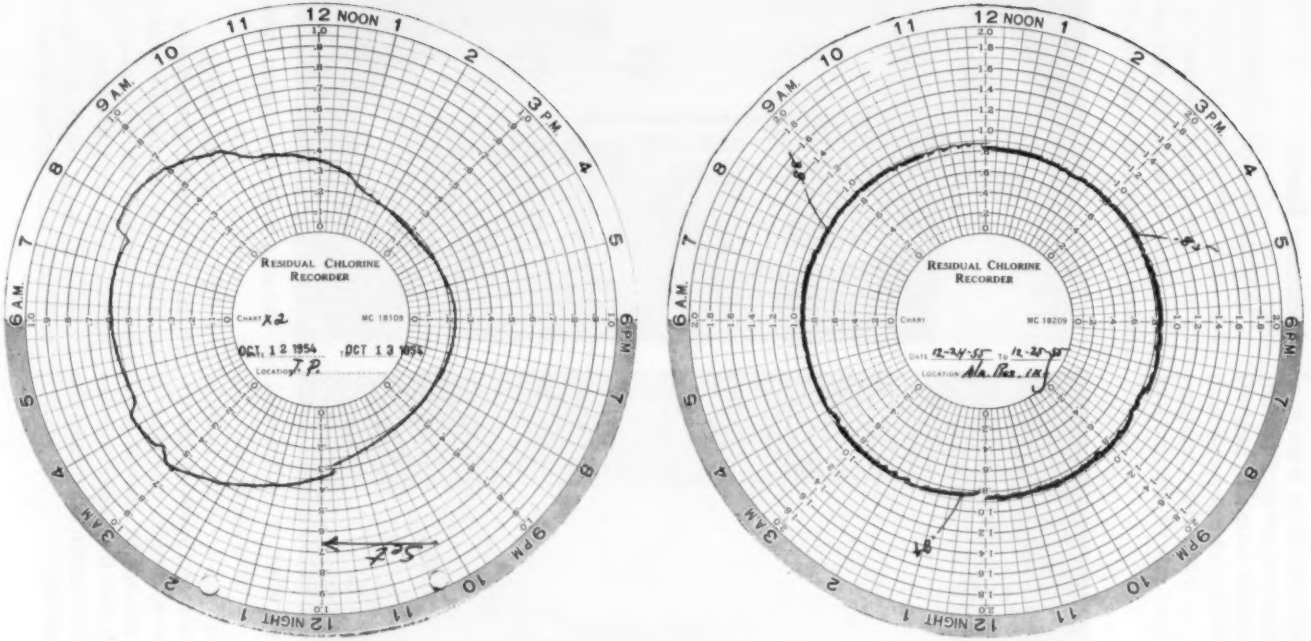

Fig. 8. Typical Residual Chlorine Charts Showing Chlorine Residual Values Before and After Residual Control

The chart at the right was made under residual control. Charts are of finished water at the treatment plant at Long Beach, Calif.

the vacuum changes the rate of chlorine feed. In the correcting device of Fig. 6, this principle is further exploited in the automatic residual control unit by impressing the vacuum from the air vacuum control chamber of the chlorine feeder to the area immediately above the surfaces of the hydraulic liquid in the filling and receiving reservoirs. (Figure 7 gives two views of the electrode and chemical solution reservoir system.) Located at the axis of the receiving reservoir is a tube, open at both ends, which is sealed into the top of the receiving reservoir to make an airtight connection between the surface of the liquid and the top of the receiving reservoir. Since the interior of the tube is subject to atmospheric pressure, the vacuum that can be exerted by the chlorine feeder is proportional to the elevation of the liquid above the tube opening. The receiving reservoir is designed in such a way that it is capable of controlling the value of vacuum from 0 to 12 in. of water (and, consequently, the rate of chlorine feed) by varying the elevation of the filling reservoir relative to the receiving reservoir. By mounting the filling reservoir on the motor-driven rack and pinion, a change of elevation produces a reestablishment of levels directly proportional to the change (since the conditions of vacuum impressed across both surfaces are identical). Response time is shortened in the process by making the area of the filling reservoir at least four times that of the receiving reservoir. For example, if the diameter of the receiving reservoir were 1 in., the diameter of the filling reservoir would be 2 in. The transfer and vacuum hose from the chlorine feeder to the two reservoirs should be of plastic tubing with common hydraulic fluid for the reservoir liquid, because it prohibits vaporization and will not attack rubber fittings and tubes. A list of the parts needed for construction of the controller detecting and correcting mechanisms is given in the appendix to this article.

Application

A typical application of the detecting and correcting elements in the residual control device would operate as follows: It is desired to hold the total chlorine residual to a certain value in the plant effluent of a particular system. A sample of the effluent is continuously passed through the cell block assembly and a 0.1-ml per minute discharge of the solution is made to enter the unit against the head established by the cell block assembly head orifice pipe. With the control knob turned fully counterclockwise and with a zero chlorine residual in the plant effluent, the zero-adjustment potentiometer is rotated until the meter relay needle is at zero center. If it is impossible to obtain a zero chlorine residual in the plant effluent this condition can be duplicated by shutting off the effluent supply to the cell block assembly and permitting the trapped sample to stand for a few minutes. The correcting device or chlorine feeder is then started manually and the total residual at the sampling point is taken either amperometrically or with orthotolidine until the combined residual equals the desired value. The cell block assembly will generate a current proportional to the quantity of chlorine present in the sample. This will deflect the needle of the meter relay from electrical zero. The control potentiometer is then rotated until some convenient position is reached (4 or 5 turns clockwise), so that, together with the range-adjustment potentiometer, the needle is just off the

contact point. The relay is rebalanced to electrical zero with the control potentiometer, and the adjustable contacts set to approximately 1.5 μa on either side of zero. (The power to the contacts should be off when making this adjustment.) At this point, there will have been established the control position which is exactly equal to the residual furnished by the chlorine feeder and the natural residual present in the plant effluent at that precise moment. The chlorine feeder is then changed from manual to automatic control and the power supply to the meter contacts energized. The control device is now on full automatic. Any external change in the total residual which is due to a fluctuation of the influent will result in a smoothly compensated chlorine rate of feed to the plant effluent which will be exactly equal to the control point residual. As a sensitivity check, if a residual recorder is available, the chart should be inspected to see if there is a wavy, sinusoidal line instead of a smooth line about the control point residual. If the line is uniform and the response time satisfactory, the sensitivity is in good adjustment. If, however, the line is irregular and the controller "hunts," the adjustable cam position should be changed in the detecting element (the cam controls the reversible motor's off and on time), or the meter relay contact points should be reset, or both contact points and cam setting should be changed.

Figure 8 shows two charts of the finished water at the Long Beach Water Department Treatment Plant which illustrate the condition of chlorine residual in the plant effluent before and after the installation of the residual controller. Note that for a 24-hr period the controller held the plant effluent residual to within 0.05 ppm of the desired 0.85 ppm.

APPENDIX

The following items (with manufacturer or source) were used in the construction of the controller detecting and correcting mechanisms already described. One cell block assembly and one electrode assembly, both products of Wallace & Tiernan Incorporated, Belleville, N. J.; one constant-head device, one chemical solution reservoir (pyrex, 2,000 ml graduate, with rubber stoppers, atmosphere discharge pipe, and glass solution and vent lines), and a cell block assembly support stand (with micrometer for chemical solution reservoir), all constructed as needed and as illustrated in Fig. 4; an aluminum sloping-front cabinet for the electrical system (8 × 8 × 10 in.), Model No. SFC-44, and a standard aluminum chassis (7 × 7 × 2 in.) Model No. A-104, both manufactured by the California Chassis Company, Los Angeles, Calif.; one meter relay (zero center, double contact, 20μa), Model 251-C, and one d-c power supply (125 v, with power relays and cam-operated interrupter), both products of Assembly Products, Incorporated, Chagrin Falls, Ohio; 6 ft of two-strand, shielded wire (# 22 B & S) from the electrode assembly, 50 ft of three-strand, plastic-covered wire from the electrical system to the reversible motor, and 25 ft of hookup wire, all manufactured by the Belden Manufacturing Company, Chicago, Ill.; two 1.25-v mercury cells, No. RM 1200, one 200-ohm potentiometer (2 w), No. C 200P, one 2,000-ohm potentiometer (1 w), No. UF Z3 R, one 20,000-ohm potentiometer (1 w), No. V 26, and one 0.5-megohm potentiometer (1 w), all products of P. R. Mallory & Company, North Tarrytown, N.Y.; one 2,700-ohm resistor (0.5 w), Ohmite Manufacturing Company, Skokie, Ill.; one reversible motor (1 rpm, 115 v, 60 cycle), manufactured by Bodine Electric Company, Chicago, Ill.; one rack and pinion (ten teeth per inch, 18-in. steel rack), a product of the Boston Gear Works, Quincy, Mass.; one stainless-steel filling reservoir and a stainless-steel receiving reservoir (with ¼-in. vacuum relief tube and ½-in. inlet and outlet pipe) constructed as needed and as illustrated in Fig. 6; and 1 qt of hydraulic fluid (Varcon), 10 ft of ½-in., 3 ft of ¼-in., and 1.5 ft of ½-in. Tygon tubing, all supplied by the Auto Supplies Manufacturing Company, Denver, Colo.

Glassy Phosphates in Water Treatment

George L. Illig Jr.

A paper presented on Oct. 24, 1956, at the Alabama-Mississippi Section Meeting, Mobile, Ala., by George L. Illig Jr., Asst. Mgr., Threshold Dept., Calgon Co. Div., Hagan Chemicals and Controls, Inc., Pittsburgh, Pa.

SODIUM phosphate glass * was first used for municipal water treatment at a small city in Ohio in the spring of 1938. Today, over 2,000 municipalities throughout the United States provide water that has been treated with glassy phosphate to prevent deposition of calcium carbonate scale, to control corrosion, to stabilize dissolved iron or dissolved manganese, or for a combination of these purposes.

Scale Prevention

The first application of glassy phosphates in the municipal water field was in the prevention of calcium carbonate incrustration following softening of water with lime and soda ash. This initial treatment was carried out under the supervision of the late C. P. Hoover (*1*) and involved the addition of 2 ppm sodium hexametaphosphate glass to the water passing from the settling basin to the filters.

Before hexametaphosphate was used, this plant experienced the difficulties with: [1] serious calcium carbonate scale deposition in the 16-in. line connecting the settling basins with the filters; [2] cementation of the filter sand because of after-precipitation of calcium carbonate; [3] scale buildup in the distribution system and [4] plugging of domestic hot-water heating coils with lime scale.

Within 48 hr after the glassy phosphate treatment was started, scale deposition in the connecting line and across the filters had stopped. This was determined by measuring the alkalinity of water samples taken at the outlet of the settling basins, ahead of the filters, and at the clear well. With glassy phosphate treatment the alkalinity values agreed within 1 or 2 ppm at all sampling locations as compared to an alkalinity drop of 30–40 ppm without the corrective treatment.

Twenty-five days after the start of treatment, sufficient alkalinity checks had been made throughout the city to establish that afterprecipitation had been stopped throughout the distribution system and in domestic hot-water heaters. The line ahead of the filters originally contained from $\frac{5}{8}$ to $\frac{3}{4}$ in. of scale that was so hard that a sample had to be chipped off with a chisel and hammer. Examination of this line, however, after 25 days of glassy phosphate treatment showed that the scale thickness had been reduced by almost $\frac{1}{4}$ in. and that the top $\frac{1}{8}$ in. of the re-

* The sodium phosphate glass (or glassy phosphate) referred to in this article is that molecularly dehydrated form which contains 67 per cent P_2O_5. Calgon brand sodium hexametaphosphate, a product of Calgon Company Division, Hagan Chemicals & Controls, Incorporated, Pittsburgh, Pa., was used in all the applications described.

maining scale had been softened to the point that it could be easily scraped off with the finger.

As a direct result of this successful trial application, the use of glassy phosphate for stabilization of lime and lime-soda softened waters quickly spread throughout Ohio and other hard water areas of the Midwest. Within 3 years, more than 200 water companies were treating their lime or lime-soda softened waters with glassy phosphate at dosage levels for the most part within the range of 0.5 to 2 ppm. The majority of these early users have continued this successful application up to the present. Among the cities using glassy phosphate for scale prevention are Columbus, Ohio; Flint, Mich.; Des Moines; Dallas; New Orleans, and Oklahoma City.

Some of these cities are feeding enough glassy phosphate to keep the filter sand from becoming incrusted; this can be accomplished with a feed rate as low as 0.5 ppm. Many operators prefer to obtain additional softening at the expense of filter sand cementation and apply the phosphate to the finished water at a rate of 1 to 2 ppm in order to keep the distribution system free of lime deposits and to prevent scale buildup in hot-water heater coils. A third group applies sufficient phosphate ahead of the filters to take care of the distribution system and hot-water heaters as well as the filters. The most economical method involves a split-feed arrangement of 0.5 ppm ahead of the filters and 1.5–2.0 ppm to the finished water. When treating unsoftened waters that are high in bicarbonate hardness, feed rates of about 3 or 4 ppm may be required at the point of application, in order to maintain a residual of 2 ppm in hot-water heaters throughout the system.

Instead of a chemical reaction, this application involves a physical phenomenon—the holding by the glassy phosphate of calcium carbonate in solution at concentrations well beyond the normal solubility limits. The most commonly accepted explanation for this states that "apparently the molecularly dehydrated phosphate acts to remove crystal nuclei from contact with the solution on the threshold of the crystallization process—that is, even before the nuclei reach dimensions great enough to exhibit the properties of the colloid state" (*2*).

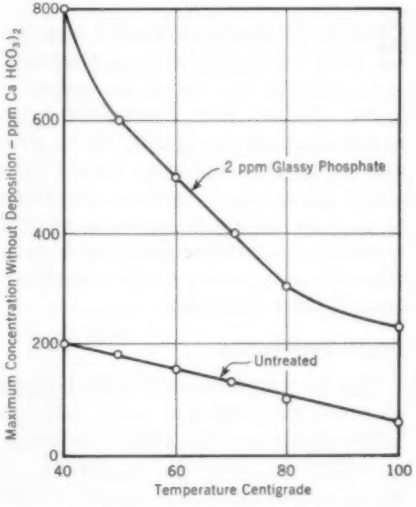

Fig. 1. Maximum Calcium Bicarbonate Concentrations Possible Without Deposition in Phosphate-treated and Untreated water

Samples were heated one hour at designated temperatures.

Nevertheless, there is a limit to the amount of excess alkalinity that glassy phosphates will successfully stabilize, and there is a marked decrease in its effectiveness at pH values above 11.0.

Figure 1 shows that the effectiveness of glassy phosphate in preventing calcium carbonate deposition also decreases with increasing temperatures, but that, even at temperatures close to the boiling point, glassy phosphate will prevent scale from occurring in waters with twice the hardness at which it occurs in an untreated water.

Corrosion Control

Although the original application of glassy phosphate was for calcium carbonate scale prevention, by far its most important application is its role as a corrosion inhibitor. Approximately 1,500 municipalities feed glassy phosphate either to prevent "red water" caused by iron pickup in the distribution system, or to minimize tubercle buildup and maintain the carrying capacity of the water mains at a high level.

Corrosion protection is provided by formation of a protective glassy-phosphate film on the metal surfaces which come in contact with the flowing water. Because the mechanism of film formation has been described in numerous papers (*3–11*), comparatively little attention will be devoted to this topic. Recent work by such independent investigators as Mansa and Szybalski (*8*), Hatch (*7*), and Lamb and Eliassen (*9, 10*) has established that sodium hexametaphosphate glass is primarily a cathodic inhibitor. It is, therefore, a safe inhibitor because there is no danger of intensifying corrosive attack even if used in concentrations that are too low to provide maximum corrosion protection.

Glassy phosphate is a versatile corrosion inhibitor because it protects ferrous metals over a wide pH range—even at values as low as 5.0. Hatch's work (unpublished) on galvanic cell reactions, however, has shown that a more effective glassy phosphate film is formed at pH values below the stability pH than in waters with a positive Langelier Index. Therefore, the most efficient corrosion inhibition is obtained at neutral or slightly acid pH values.

An inhibitor concentration of only a few parts per million will provide the desired corrosion protection in most cases. This leaves the water unaltered to any measurable degree since the phosphate glass is colorless, tasteless, odorless, and essentially neutral. The water acts as a medium to bring the glassy phosphate into contact with metal surfaces of the distribution system, and the actual feed rate is largely dependent on the flow characteristics of the distribution system. The protective film does not build upon itself and, therefore, does not impede the flow of water. The film, however, is not permanent, and continuous treatment is necessary to maintain it.

The glassy phosphate film functions efficiently at all temperatures up to the boiling point although higher feed rates are required at elevated temperatures because the rate of corrosion attack is more rapid. The treatment is effective against the usual corrosive constituents of the water such as dissolved oxygen, carbon dioxide, sulfates, and chlorides. One exception is hydrogen sulfide which must be removed from the water by aeration, chlorination, or a combination of aeration and chlorination.

A small amount of calcium is necessary to permit formation of the protective film (*5*), which explains why effective corrosion protection will not be provided by glassy phosphate in distilled water, demineralized water, or in zero-soft, zeolite-treated waters. A minimum of 1 ppm of calcium (as calcium ion) is required to support a

glassy phosphate feed rate of 5 ppm, but optimum results will be obtained with a ratio of at least 1 part of calcium for every 2 parts of phosphate. Even though the problem is seldom encountered in treating municipal water supplies, it is important when treating hot-water systems or industrial water systems using completely soft waters. When necessary, additional hardness can be obtained by feeding a calcium salt such as calcium chloride, or by bypassing a small percentage of the raw water around the softening equipment.

The point of application is not critical when glassy phosphate is used for corrosion protection although it is normally fed to the filtered water at the clear well. It should not be fed ahead of coagulation and sedimentation basins because the glassy phosphate will be pulled down on the floc, and an excess of coagulant will be required for good clarification.

Although the feed rate for a given system will be dependent on the volumetric flow rate, control of the feed should be based on maintaining a metaphosphate residual of approximately 0.5 to 1.0 ppm at the extreme ends of the system. Generally speaking, larger cities with high-mass flow rates will require an average feed of about 2 ppm, and smaller systems with low-mass flow rates may require as much as 5 ppm. In unusual cases smaller systems may require 10 ppm.

The experience of a water utility in western Pennsylvania illustrates this point. Glassy phosphate treatment has been used there to prevent iron pickup, with control based on a metaphosphate residual of 0.5 ppm at the dead-end areas of an extensive distribution system. The system pumps 18–20 mgd of clarified river water with an average hardness of 86 to 103 ppm. Although the raw water contains up to 4 ppm of manganese and 2 ppm of iron during certain seasons of the year, the finished water consistently contained less than 0.05 ppm of manganese and no more than 0.1 ppm of iron. Before phosphate treatment, however, iron values of about 0.5 to 1.0 ppm were obtained at dead-end locations despite pH adjustment with lime to maintain a positive Langelier Index.

Treatment was started at 300 lb per day (equivalent to 2 ppm) with the glassy phosphate applied to the clear well as a water solution by means of a chemical feed pump. At the same time the pH was reduced to a range of 7.3–7.5. The 2 ppm feed level was maintained until a metaphosphate residual of at least 0.5 ppm appeared at selected dead-end sampling locations. Typical analyses of the finished water leaving the plant and at a dead-end sampling location are shown in Table 1. In the interest of economy the feed rate was gradually reduced in decrements of 0.25 ppm per week to determine what minimum feed rate would be required to maintain the 0.5 ppm mini-

TABLE 1

Analysis of Water in Western Pennsylvania Community Using Glassy Phosphate

Substance	Finished Water Leaving Plant *ppm*	Dead End Location *ppm*
Bicarbonate	30	28
Chloride	17	18
Iron	0.07	0.09
Manganese	>0.05	>0.05
Calcium	31	31
Magnesium	5	6
Hardness ($CaCO_3$)	99	101
Metaphosphate	1.3	0.6
Orthophosphate	0.2	0.6
pH	7.4	7.4

mum metaphosphate residual. Good results were obtained at feed levels of 1.75, 1.50 and 1.25 ppm, with virtually no iron pickup (a maximum of 0.1 ppm). When the feed rate was decreased to 1.0 ppm, the metaphosphate residual dropped to 0.1 ppm or less, and the iron pickup increased by 0.2 or 0.3 ppm by the end of 1 week. The treatment level was returned to 1.20–1.25 ppm which was found to be the minimum feed rate required both to prevent iron pickup and to maintain the recommended 0.5 ppm metaphosphate residual. Further experimentation with feed rates in the vicinity of 1 ppm was carried out on several occasions in this system. The same results were experienced and definitely established that a minimum glassy phosphate feed rate of approximately 1.25 ppm was needed under the existing operating conditions.

At the same time, a smaller water utility in the same section of Pennsylvania was using water from the same river and following similar clarification practices. Here, a glassy phosphate feed rate of 3 to 3.5 ppm was needed to obtain minimum metaphosphate residuals of 0.5 ppm. The smaller utility also has an extensive distribution system of more than 40 miles of transmission and distribution mains, but it serves residential areas almost exclusively, with less than 3,000 customers. The normal pumping rate is 400,000 gpd, and from 10 to 12 lb of glassy phosphate supplies the daily feed requirements.

The importance of volumetric flow rate is further demonstrated by the experience of a resort community on the Eastern Seaboard which has a summer pumping rate of more than 2 mgd and a winter pumping rate of only 400,000 gpd. During the summer, good corrosion protection was provided by a 2-ppm feed rate, but during the winter months a 5-ppm feed rate (based on the lower pumpage rate) was needed to prevent iron pickup under the relatively sluggish flow conditions in this extensive distribution system. Typical analyses for this low hardness, low total solids water are shown in Table 2 both for summer and winter operating con-

TABLE 2

Analysis of Water in an Eastern Seaboard Community With Wide Seasonal Variations in Pumping Rate *

Substance	Summer, 1954		Winter, 1954	
	Finished Water at Plant—*ppm*	End of System *ppm*	Finished Water at Plant—*ppm*	End of System *ppm*
Bicarbonate	16	18	18	20
Chloride	10	11	15	16
Iron	0.10	0.12	0.12	0.13
Calcium	5	5	4	5
Magnesium	1	1	2	2
Total Hardness ($CaCO_3$)	17	17	19	20
Metaphosphate	1.8	0.5	4.2	0.4
Orthophosphate	0.3	0.5	0.6	0.8
pH	7.2	7.2	7.4	7.3

* Pumping ranged from a summer rate of more than 2 mgd to 0.4 mgd in the winter. Glassy phosphate was fed at a rate of 2 ppm in the summer and 5 ppm in the winter.

ditions. Before starting glassy phosphate treatment, pH adjustment with lime had been unsuccessful both in controlling red water and tuberculation, and, as a result, the lime feed was gradually eliminated several weeks after initiating phosphate treatment.

When glassy phosphate treatment is first started, it is sometimes advisable to employ an initially high feed rate of 5 to 10 ppm for at least one week in conjunction with a systematic fire hydrant flushing program. This serves the twofold purpose of speeding formation of the protective phosphate film and of purging the system of loosely adherent, deposited matter. There are also occasions when it is necessary to avoid disturbance of existing deposits, and, under these circumstances, a starting feed rate as low as 0.5 ppm is advisable, with a gradual increase to the normal feed rate over a period of 6 to 8 weeks.

Secondary pH adjustment with lime, soda ash or other alkali is seldom required in conjunction with glassy phosphate treatment, which yields superior results in controlling corrosion and in eliminating red-water complaints. Since glassy phosphate will permit operation at lower pH values, the tendency toward tuberculation will be reduced for this reason alone. In addition, the glassy phosphate will also minimize tubercle formation and help to maintain flow capacities. Storage and handling facilities are much simpler with glassy phosphate. In some cases where soda ash or caustic soda is used for pH adjustment, an actual saving in chemical costs will be realized although this would not be true for low-solids waters which would require only a few parts per million of alkali for pH adjustment. The use of glassy phosphate will prevent the uneven deposition of calcium carbonate in water mains and meters that is frequently experienced with lime treatment. Finally, the consumer is provided with a softer water than would be obtained if lime were used for secondary pH adjustment of the finished water. In the low concentration used, glassy phosphate will not soften the water by a measurable amount because, in order to achieve complete softening, a concentration of 6 ppm is required for every part per million of calcium carbonate hardness.

Water Main Cleaning

Of the more than 1,500 water plants using glassy phosphates for corrosion control, it is probably true that the majority started treatment primarily to overcome red water complaints. A much more important reason for using glassy phosphate is reduction of the rate of tuberculation and the maintenance of high-level carrying capacity of the mains. This will result not only in savings in pumping costs but may avoid the need for new or oversized mains.

Tuberculation is extremely difficult to control after mechanical cleaning of water mains because the pipe surfaces are scraped free of old deposits and protective coatings and the newly exposed metal is very susceptible to corrosive attack. Tubercle buildup in unprotected lines is rapid immediately after the cleaning operation, and, in severe cases, the cleaning may be needed two or three times a year. This is true even though the line may have been in service for 25 years or longer before its original cleaning. Red water complaints also are encountered as a result of the cleaning unless corrective measures are taken.

One obvious remedy is the mechanical application of cement lining or other

protective coating immediately after the cleaning operation. Glassy phosphate treatment represents a much less expensive approach to the same problem. It has provided outstanding results in combating the red water and the rapid rate of tubercle buildup which are associated with mechanical main cleaning.

As might be expected, a higher than normal phosphate feed rate is needed during and immediately after the cleaning operation in order to protect the freshly exposed metal. Therefore, a glassy phosphate concentration of about 50 to 100 ppm should be maintained in

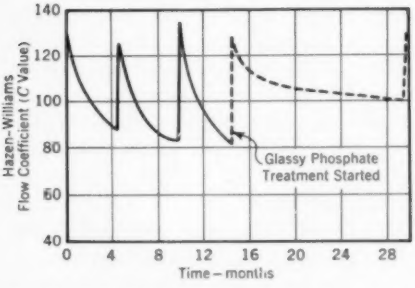

Fig. 2. Effect of Glassy Phosphate Treatment on Flow Coefficients

Data were compiled on a 16-in. water main after mechanical cleaning

the water used to force the cleaning tool through the line and in all of the flush water. The necessary phosphate concentration will depend on the calcium ion content of the water, and should not exceed five times the calcium value. Therefore, when extremely soft waters are involved, it may be necessary to feed calcium chloride or lime to supply the calcium needed to support a 50 ppm feed rate.

The complete procedure involves the application of glassy phosphate at a feed rate of 2 to 5 ppm for at least 10 days before the cleaning operation in order to be certain that the system contains a good metaphosphate protective film. The high concentration of 50 to 100 ppm is used during the cleaning operation, followed by a 10 ppm feed rate for the first week after the cleaning before return to the normal feed level for continuing treatment.

The suggested procedure was followed with gratifying results by one of the northern water companies which cleaned, for the first time, a 3-mile length of 8-in. cast-iron main during the summer of 1953. The Hazen-Williams flow coefficient or *C* value which was slightly below 50 before cleaning was brought up to 120 immediately afterward. Calculations by the supervising engineer indicated that the cost of glassy phosphate treatment could be justified if the *C* value did not drop below 80 by the end of the first year. Although a rapid initial decrease to a level of 100 was experienced during the first 3 months, the rate of drop was checked so effectively that the *C* value remained in the 90's, for the balance of the first year. By the end of the second year, *C* values were obtained within the range of 80 to 90, and, even at the end of the third year, the *C* value was just a little below 80. The *C* value has leveled off so close to 80 that additional cleaning has been postponed indefinitely.

This experience provides an interesting contrast to that of one of the water districts in the East where, before the use of glassy phosphate, cleaning of a 16-in. transmission line was required every 4 to 6 months. As shown in Fig. 2, the initiation of phosphate treatment successfully permitted operation for 15 months without cleaning. Without glassy phosphate treatment the *C* value was, of necessity, allowed to drop to a range of 80 to 90, in order

to lengthen the time between cleaning operations. On the other hand, while glassy phosphate was used, the line was cleaned when the *C* value dropped to only 100. Even with this limitation, one cleaning cycle extended over a 15-month period with glassy phosphate as compared with less than 15 months for 3 cycles without glassy phosphate.

A comparable case history is outlined in a paper by Haney (*12*) describing conditions at Charlottesville, Va., where frequent cleaning of a 17-mile, 18-in., cast-iron transmission line was required. Before glassy phosphate treatment was started, both lime and chlorination were tried singly and in combination in an attempt to keep the capacity of the main at a high level. Comparatively little benefit resulted, however, cleaning being required every 4 to 6 months. After mechanical cleaning in April 1951, lime treatment was discontinued and glassy phosphate treatment started at a feed rate of 2.5 to 3.0 ppm. Even though a high dosage was not used during or immediately after the cleaning operation, 11 months passed before the next cleaning in March 1952. Haney also points out that in addition to increasing the period between cleaning by 100 to 200 per cent, glassy phosphate treatment eliminated the need for operating the booster pumps on the transmission line even during the peak demand periods. This resulted in a saving of $40 per day in power costs alone that more than paid for the chemical treatment. A third benefit was the elimination of red water complaints.

In a recent paper, O'Hara (*13*) described a test of the effectiveness of glassy phosphate treatment in overcoming red water and tubercle buildup. In 1947, at Arlington, Mass., two water mains in adjacent sections of the same distribution system were mechanically cleaned. One section was supplied with water containing approximately 2 ppm glassy phosphate while the other section received the identical water without phosphate. The glassy phosphate was completely successful in overcoming red water, and flow capacities in the section of the system receiving the phosphate treatment were markedly higher than in the untreated section. When the pipelines were opened for inspection approximately 8 years later, the marks of the cleaning tool were still visible in the phosphate treated line, with very little evidence of tubercle buildup. The untreated line, on the other hand, showed marked tuberculation and an accumulation of corrosion products. As a result of this experience city officials at Arlington plan to extend glassy phosphate treatment to include all sections of their distribution system.

Although the use of high concentrations of regular sodium hexametaphosphate has proved to be quite successful in conjunction with mechanical cleaning of water mains, even greater promise has been demonstrated by a specially produced zinc-bearing phosphate glass (*15*).* This compound speeds the rate of formation of the protective film and is ideally suited for this application. Its use during main cleaning will further reduce the rate of tubercle buildup and maintain *C* values at an even higher level than regular glassy phosphate.

In this application, concentrations equal to twice the total hardness for soft waters and up to a maximum of 50 ppm for medium and hard waters should be used during the cleaning and

* Calgon, Composition TG, also a product of Calgon Company Division, Hagan Chemicals & Controls, Inc., Pittsburgh, Pa.

flushing periods. This should be followed with treatment for at least 1 week after the cleaning operation at a 5 to 10 ppm level. Continuous treatment with regular glassy phosphate should then be adequate to hold the film in good repair throughout the distribution system.

Although this represents a relatively new application in municipal water treatment this new product has been

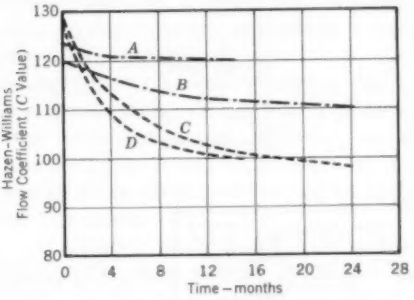

Fig. 3. Effects of Regular and Zinc-bearing Phosphates on Flow Coefficients

Curves A *and* B *are for systems in which the new zinc-bearing phosphate was used during mechanical cleaning: Curves* C *and* D, *those in which regular phosphate was used. Although data obtained were from four different systems, the water involved had similar characteristics—low in dissolved solids and relatively soft. All data were taken following the mechanical cleaning of the mains.*

used in industrial water systems for the past 5 years when severe corrosion conditions have been encountered. Within the past several years, two northeastern water utilities have used the treatment successfully in conjunction with mechanical main cleaning. In both cases *C* values have leveled off higher than would be expected with regular glassy phosphate treatment. The results for these two systems are shown in Fig. 3, with *C* values obtained for two other systems where regular glassy phosphate was used. Although these data were obtained from four different systems, the four waters involved have similar water characteristics in that they are relatively soft and low in dissolved solids. The results indicated by Curve *A* on the graph are discussed in complete detail in a recent paper by Monie and Scales (*14*). The authors report that the *C* value has held at 120 for 14 months after the cleaning operation which was carried out in June 1955. Before cleaning, the *C* value had dropped to 56. They were also pleased to find that no red water complaints were received after the cleaning operation.

Iron and Manganese Stabilization

All too frequently red water complaints can be blamed on the oxidation and precipitation of dissolved iron which is naturally present in a well water supply. Similarly, complaints of black water frequently can be traced back to soluble manganese in the well water. Fortunately for many water department superintendents, that versatile chemical, glassy phosphate, will successfully stabilize dissolved iron and manganese.

Unlike its corrosion control application, in iron and manganese stabilization, the glassy phosphate must be fed in proportion to the amount of iron and manganese in the water supply. Under normal conditions, a ratio of 2 parts of glassy phosphate for every part of iron and every part of manganese is required. If breakpoint chlorination is being practiced, or if the pH is 8.0 or higher, a feed ratio of 4 to 1 should be used. A 4 to 1 ratio is also advisable during the first week or two of treatment in those cases where the system

contains an accumulation of old iron or manganese deposits. The initially high feed rate should be accompanied by a systematic hydrant-flushing program. Furthermore, a minimum feed rate of 2 ppm is required if the sum of the iron and manganese values is less than 1 ppm.

An equally important consideration is that glassy phosphate be mixed thoroughly with the water before aeration, chlorination, or the addition of any oxidizing substances to the water supply. This is necessary to enable the phosphate to tie up the iron and manganese before their oxidation and precipitation occurs. For this reason, glassy phosphate should be fed directly to the well to the suction level of the well pump when dissolved iron or manganese are present in concentrations greater than 0.2 to 0.3 ppm. A schematic diagram of typical glassy phosphate feed equipment is shown in Fig. 4.

Another important factor in this treatment involves iron bacteria which must be controlled by proper disinfection with chlorine or one of the hypochlorites if the maximum benefits are to be realized from the glassy phosphate. This results from the fact that iron bacteria which are naturally present in the water supply can oxidize and precipitate iron and manganese oxides even in the presence of glassy phosphates.

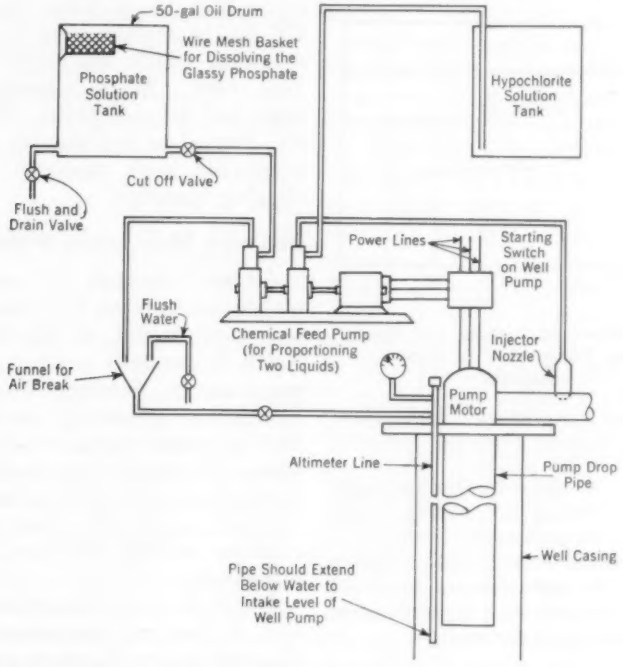

Fig. 4. Diagram of Typical Glassy Phosphate Feeding System

There is, apparently, a common misconception that glassy phosphate treat-

ment will prevent the oxidation of dissolved iron and manganese because it is necessary to feed the glassy phosphate before the water is exposed to oxidizing substances. In actuality, the phosphate is merely adsorbed on tiny particles of iron oxide and manganese oxide, and this keeps the individual particles separated and prevents their growth to a size where precipitation can occur. Under conditions usually encountered in a municipal distribution system, glassy phosphate treatment will stabilize dissolved iron and manganese for a week or longer. With water containing as much as 2 ppm of iron and manganese, however, some discoloration of the water may be observed after prolonged heating at high temperatures.

At present, many municipalities use glassy phosphate treatment for stabilization of dissolved iron or manganese. In most cases, the iron and manganese totals will be within the range of 0.5 to 2.0 ppm although there is no theoretical limit to the amount of iron and manganese that can be stabilized if glassy phosphate is fed at the proper ratio. As much as 25 ppm of dissolved iron in a private well supply has been stabilized by a 50-ppm glassy phosphate feed rate. In this case the water was not used for drinking or cooking, but for all other purposes including cleaning and sanitation. For larger public water supplies there is obviously an economic limitation on the amount of iron and manganese that can be stabilized; this will usually vary between 2 and 5 ppm, depending on the amount of water pumped.

Although it is necessary to feed glassy phosphate to the water before aeration or chlorination to be certain of obtaining optimum treatment results, it is not always necessary to feed directly to the well. Some users have obtained successful results by applying the glassy phosphate to a common header, which is fed by two or more wells, or by feeding the phosphate to one well which later mixes with water from one or more additional untreated wells. In such cases, treatment results will be good if adequate mixing of the phosphate is obtained and if the water does not contain dissolved oxygen or chlorine at the point of application.

Several municipalities have successfully fed glassy phosphate to filtered water to tie up residual iron and manganese not removed in the treatment plant. Results with such treatment were particularly successful at a city in West Virginia where the finished water contained up to 1.0 ppm of soluble manganese for a 5- or 6-year period until completion of a plant addition permitted more complete manganese removal within the plant. Glassy phosphate was applied at a 2-ppm rate to the water leaving the filters, but before postchlorination. Similar results were obtained at plants in Indiana and Pennsylvania where the finished water contained 0.5 ppm to 1.0 ppm of iron and manganese and was successfully stabilized with glassy phosphate feed rates of 2 to 3 ppm. Further experiences with glassy phosphate in dissolved iron stabilization are discussed by such authors as Rice (*4, 6, 16*), MacArthur (*17*), Mayhan (*18*), and others.

Feeding Equipment

For municipal water treatment, unadjusted sodium hexametaphosphate in the form of broken-glass platelets is normally specified. The platelets are readily soluble in water and should be fed as a water solution of convenient strength. Although the chemical has no limiting solubility, a maximum solu-

tion strength of 1 or 2 lb per gallon of water is suggested for ease of feeding. Either gravity flow feeders or chemical feed pumps can be used.

Since *concentrated* sodium hexametaphosphate feed solutions are corrosive to ordinary iron and steel in the absence of sufficient calcium for film formation, corrosion-resistant equipment should be used. Chemical feed pumps should be equipped with stainless-steel or plastic pump parts. Feed tanks, connecting lines, and fittings should be stainless steel, plastic, rubber, plastic- or rubber-lined steel, or ceramic. If iron and steel feeding equipment must be used, reasonably good service life can be obtained by adjusting the feed solution with soda ash or caustic to a pH of 9.5.

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Maintenance of Rock Wells

Claud R. Erickson and Ralph C. Wright

A paper presented on Sep. 13, 1956, at the Michigan Section Meeting, Kalamazoo, Mich., by Claud R. Erickson, Mech. Engr., and Ralph C. Wright, both with the Board of Water and Elec. Light Comrs., Lansing, Mich.

THE city of Lansing, Mich. and the metropolitan area adjoining obtain their water supply principally from rock wells drilled into the water-bearing sandstones of the Pennsylvanian formation which is common to the area. The sandrock is encountered at depths of 50 to 150 ft and extends to a depth of 400 to 450 ft below the ground level. At greater depths, limestone and highly mineralized water (especially that high in chlorides) may be encountered. The city operates some 100 wells with a total capacity of approximately 30 mgd. Average daily production is approximately 18 mgd. Sixty-four of the wells are equipped with deep-well turbine pumps and 36 are pumped by air. The deep-well turbine pumps are set at 200 to 220 ft and the diameter of the wells ranges from 6 to 14 in. Drilled over a period of 47 years (1909 to 1956), the Lansing wells are generally located along water transmission mains which supply the water conditioning plant with untreated water. The transmission mains extend from the southeast to the northwest sections of the city. The wells are spaced at distances of 300 to 1,500 ft, with 1,000 ft the optimum spacing.

Some idea of the problem of maintaining the yield and life of the wells can be seen from the fact that fifteen new wells drilled in 1935 had an initial yield of 12.4 gpm per foot of drawdown, and a yield of only 2.5 gpm per foot of drawdown 11 years later. This is an 80 per cent drop in yield in 11 years. Decrease in the specific capacity, or yield per foot of drawdown is attributed to increased pumpage from the area and plugging of the sandrock along the sides of the wells. Increased pumpage from the Lansing area has caused a gradual lowering of water levels which seems to have adversely influenced the yield per foot of drawdown. The concern here, however, is with the plugging of the wells which is atttributed to fine particles of sandrock and shale, and the precipitation of iron and calcium carbonate on the sides of the wells. Samples of sandrock removed from the wells indicate most of the plugging does not extend more than 0.5 in. from the side of a well into the sandrock.

Several methods have been used in an effort to keep the wells operating at original capacity:

1. Treatment of the well with dry ice
2. Acid treatment
3. Reaming the sides of the well
4. Chemical treatment
5. Dynamiting.

Dry-Ice Treatment

Two wells were treated with dry ice in an effort tc recover the loss in yield. The expectation was that the carbon

dioxide released from the dry ice would change the insoluble calcium carbonate (deposited in the sandrock on the sides of the well) to soluble calcium bicarbonate. It was also expected that the boiling and surging action of the dry ice gasifying would help clean the sides of the well. In the first well treated with dry ice, 100 lb of the ice were added in 6-in. cubes and followed with an additional 200 lb 45 min later. The expected boiling action was observed for 20 to 30 min with the first 100 lb added, and for 30 to 45 min with the 200 lb of ice added 45 min later. The casing was filled with a white mist of water vapor and carbon dioxide gas which escaped slowly to the atmosphere. To determine the results of the dry-ice treatment, the well was tested under identical conditions before and after the dry ice was added. The yield before dry-ice treatment was 2.17 gpm per foot of drawdown and after treatment, 2.34 gpm. The original yield of the well in 1927, 8 years before the dry-ice treatment, was 6.8 gpm per foot of drawdown. Results indicated a 7.5 per cent increase in yield due to the dry-ice action. This was not considered very satisfactory, but it was decided to try the dry-ice treatment on another well. It was decided to apply 500 lb of ice as fast as possible and then close a valve at the top of the well casing in order to build up more pressure in the well. It was thought that the pressure might force the carbon dioxide gas back into the rock formation where it could do more good. When the dry ice was added, a maximum pressure of 14 psig was built up in 3.5 min; at the end of 8.5 min the pressure had returned to zero. Results of this treatment were no better than those on the first well treated and the method was abandoned.

Acid Treatment

After further study, it was decided to try acid treatment on one well. This work was carried on under the supervision of an experienced oil well acid-treatment concern. In the experiment,

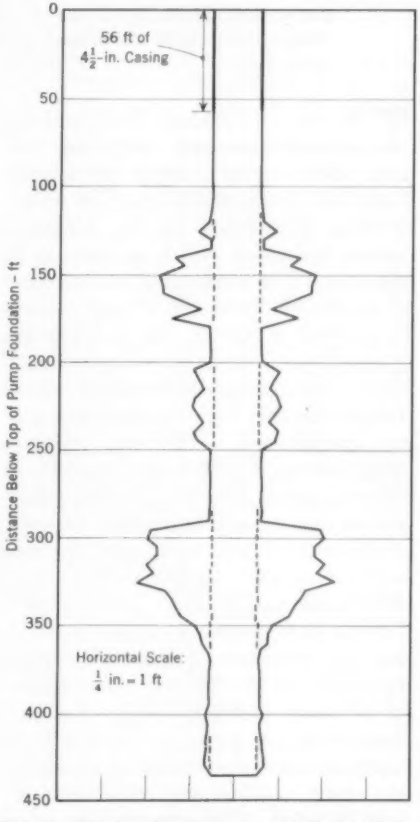

Fig. 1. Typical Enlargement of Rock Well by Dynamiting

the deep-well turbine pump was left in the well in the hope that the acid would exert some cleaning action on the pump as well as on the casing. The pump was raised about 2 ft above the foundation, and two 1-in. rubber hoses and a thermocouple wire were lowered into

the well. Two feet of lead pipe were attached to each hose to keep it straight. The hose was marked every 10 ft and the thermocouple wire was taped to one of the hose lines. The water in the well was first heated to a maximum temperature of 174°F with 2,000 gal of 190°F water from a city street-flushing truck, but the water in the well averaged only 126°F during the period that acid was being added. Live steam from a pumping station was used to heat the water in the flushing truck before it was delivered to the well. The object of heating the well water was to increase the action of the acid. The hot water was added between the 190 and 290 ft levels, because this was the best water-bearing area of the well. Immediately after the 2,000 gal of water was added, 500 gal of 18°-Baumé commercial hydrochloric acid with no inhibitor were pumped into the well, starting at 290 ft, working up to 190 ft, and then back to 290 ft. No inhibitor was added as it was felt that the concentration would be too weak and contact time too short to do any damage. After the acid was added, the hose was washed out with 200 gal of cold water, and 500 gal of cold water was added to the well about an hour later. This was done to force the acid back into the sandrock. The acid was left in the well, surged with the pump for about 4 hr, and then pumped out. Approximately 2 hr were needed to pump out all the acid—as determined by titrating samples from the pump discharge. Tests run on the well before and after the acid treatment indicated the well capacity had not been increased; the yield before treatment had been 5.9 gpm per foot of drawdown, and after treatment was 5.8 gpm per foot of drawdown. This well had an initial yield when drilled in 1935 of 9.2 gpm per foot of drawdown. The results were very disappointing and no other attempts at acid treating have been made. The cost of acid treating this well was $716.64 in 1941.

Reaming

The next method tried was reaming the sides of the well in the same manner that boiler tubes are reamed for scale removal. Most of the wells are 14-in. OD cased, 13.25-in. ID wrought-iron pipe. An air-operated rotary reamer was therefore purchased. This had a diameter of 12¾ in. when not in operation, which would permit easy passage through the 13¼-in. ID casing. The reamer had three cutter heads located on arms which expanded to 15.5-in. diameter when the reamer was rotated by the air-operated motor. This would theoretically cut 1–1.5 in. from the side of the well. This method was used on two wells, but it was found that sufficient material could not be removed from the sides of the well. After 10 hr of reaming, only about 10 in. of fill had accumulated in the bottom of the well. Little, if any, improvement in yield was obtained.

Treatment With Glassy Phosphate

After reaming the sides of the well was found unsuccessful, sodium hexametaphosphate treatment was tried on two wells. In this work the manufacturer's recommendations were followed. The pump was left in the well because it was needed for surging and because it was hoped also that the pump might be cleaned together with the well. Briefly, the treatment was as follows: A specified amount of sodium hexametaphosphate was placed in solution and allowed to flow into the well. A series of surging operations was then set up by placing the pump in opera-

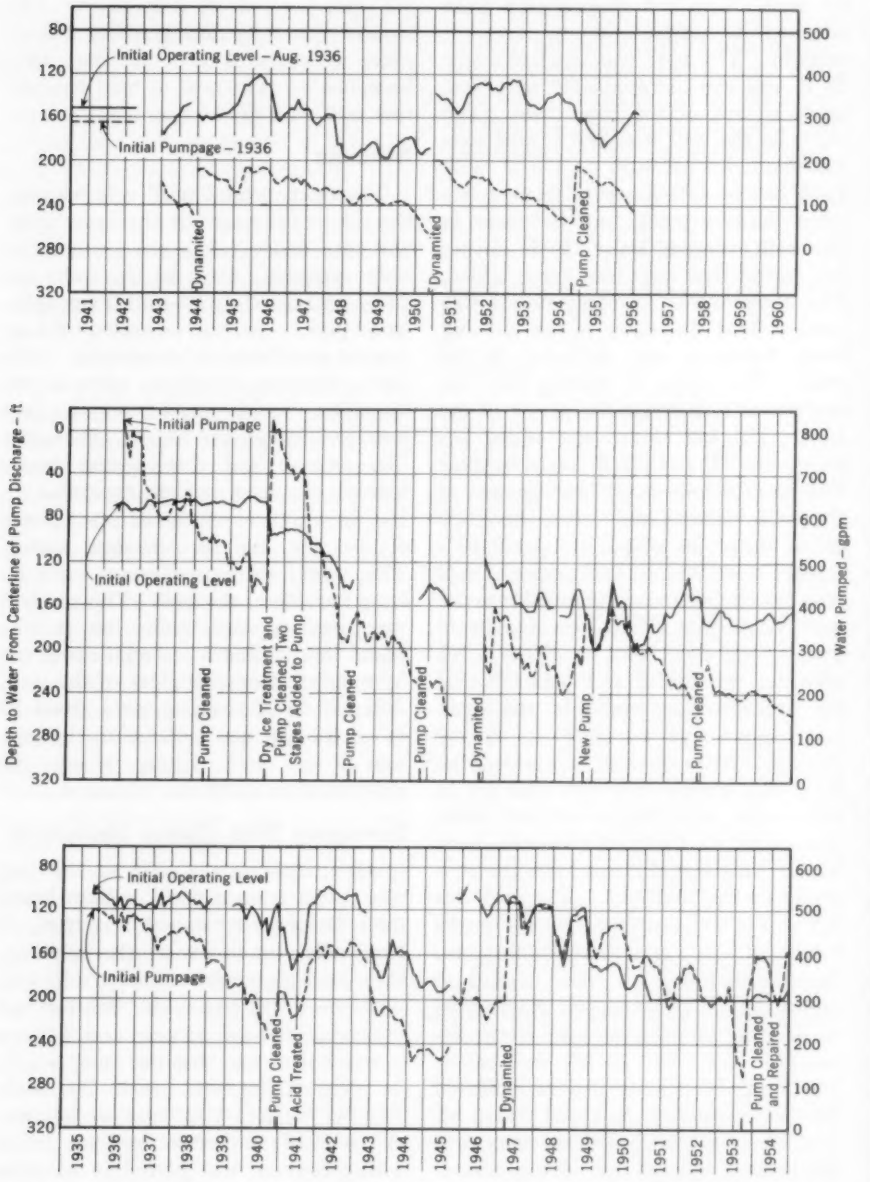

Fig. 2. Pumpage and Water Level Charts of Three Wells Treated by Methods Indicated

The solid line represents the operating level, the broken line the water pumped.

tion for sufficient time to raise the water in the pump column to the point of discharge at the surface. The pump was then shut off and the water allowed to fall back into the well, thus producing a scrubbing action in the pump and on the sides of the well. A timer was used to operate the pump in a 15-sec on, 9.75-min off cycle. This surging was continued for 72 hr after each charging with sodium hexametaphosphate. Five separate charges were made, three of 100 lb each and two of 400 lb each. The 100-lb charge was fed at a rate of 6 lb per 100 gal of water in the well, and the 400-lb charge was fed at 16 lb per 100 gal. Some benefit was obtained from this method of cleaning, both in the well and pump. The well yield was increased 44 per cent, from 3.4 gpm per foot of drawdown before treatment to 4.9 gpm after treatment. About 50 per cent of the precipitated iron oxide sludge on the pump bowls and column was removed. Some of the benefit indicated may have resulted from surging the well and may not have been due to the chemical added. The cost of the five sodium hexametaphosphate treatments, including the surging, but exclusive of pulling and reinstalling the pump for inspection, was $205.27 in 1949.

Dynamiting

The present method of routine well maintenance and the only method which has given satisfactory results is the use of dynamite. To date 71 wells have been dynamited; 48 of these have been dynamited once, 21 twice, and two three times. The procedure followed in dynamiting is as follows:

1. A study is made of the drilling log of the well and an $8\frac{1}{2} \times 11$-in. drawing made showing the various formations and the well casing. Instructions are then given to the maintenance crew to dynamite only in water-bearing sandrock and not closer than 10 ft from shale formations or 50 ft from the bottom of the well casing. Shots in the sandrock are made every 5 ft.

2. Fifty per cent nitroglycerine dynamite is used and 10-lb shots are made at each 5-ft interval.

3. The 10-lb charges are set off separately, each wrapped in cheese cloth and lowered into the well by means of the electrical detonating wire which is marked to indicate the exact level at which each shot is made. When the charge reaches the proper level, it is detonated, the wire withdrawn, and another 10-lb shot attached, lowered, and detonated. This is continued from the bottom of the well to the top, until all the sandrock has been dynamited.

4. After the dynamiting is completed, a well rig is moved in and the sandrock which has been blown off the sides of the well is bailed out. Usually, the well fills up to 100–150 ft. Twenty to 30 yd of material is taken out in cleaning the well to the original depth. This includes sand and rock which caves in during bailing the well.

5. After the well is cleaned, an old pump is installed and the well pumped until the water is clear. (An old pump is used to lessen the wear on the regular pumping unit.) During the pumping period, much sand and loose rock drops to the bottom of the well which must then be bailed out again. An additional 20 yd of material may be removed at this time. After this cleanout the regular pump is reinstalled.

Both stationary and portable well houses are used at Lansing, and the dynamiting and cleaning work can be done equally well in either type. With 10-lb shots, little, if any, water blows

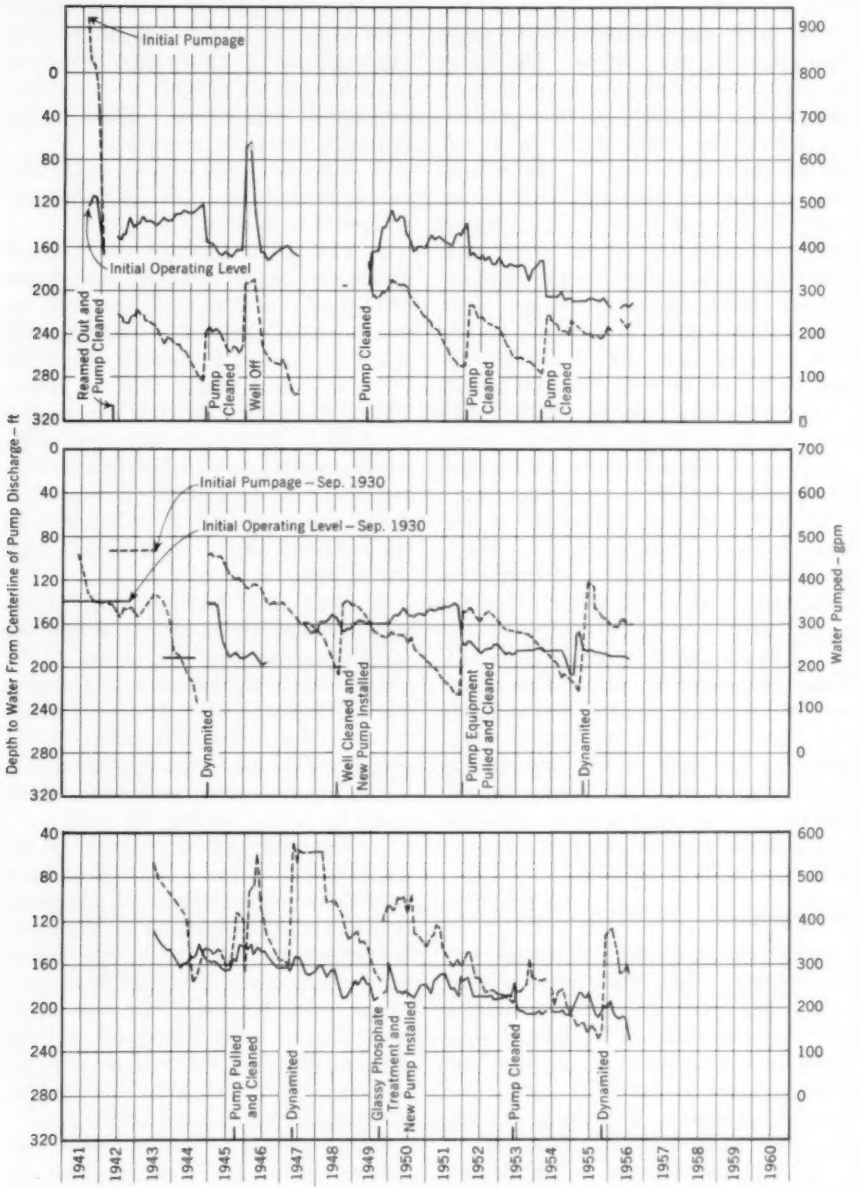
Initial Pumpage
Initial Operating Level
Reamed Out and Pump Cleaned
Pump Cleaned
Well Off
Pump Cleaned
Pump Cleaned
Pump Cleaned
Initial Pumpage – Sep. 1930
Initial Operating Level – Sep. 1930
Dynamited
Well Cleaned and New Pump Installed
Pump Equipment Pulled and Cleaned
Dynamited
Pump Pulled and Cleaned
Dynamited
Glassy Phosphate Treatment and New Pump Installed
Pump Cleaned
Dynamited
Depth to Water From Centerline of Pump Discharge – ft
Water Pumped – gpm
0 40 80 120 160 200 240 280 320
900 800 700 600 500 400 300 200 100 0
0 40 80 120 160 200 240 280 320
700 600 500 400 300 200 100 0
40 80 120 160 200 240 280 320
600 500 400 300 200 100 0
1941 1942 1943 1944 1945 1946 1947 1948 1949 1950 1951 1952 1953 1954 1955 1956 1957 1958 1959 1960

Fig. 3. Pumpage and Water Level Charts of Three Wells Treated by Methods Indicated

The solid line represents the operating level, the broken line the water pumped.

out the top of the well. In the stationary houses, the well rig is backed to the door and the cable run over pulleys which are suspended from the ceiling of the well house and from a special bracket mounted on the front of the well rig. The portable houses are moved off the well, permitting the rig to work directly over it. Several of the wells have been calipered after dynamiting, and holes as large as 6 ft in diameter have been measured. Usually the diameter of the well is increased from 14 in. to about 24 in. on the first dynamiting, with further increases on the second and third dynamitings. Typical changes in diameter which result from dynamiting are shown in Fig. 1.

Results obtained from dynamiting, and the cost of the work may be summarized as follows:

1. The initial dynamiting of 48 wells increased the specific capacity of the wells from 2.7 gpm per foot of drawdown to 6.4 gpm per foot of drawdown, an increase of 137 per cent as determined from actual pumping tests before and after dynamiting. The yield of some of these wells was better after dynamiting than when originally drilled. Thirteen representative wells had an average specific capacity of 7.3 gpm per foot of drawdown when originally drilled and 7.1 gpm per foot of drawdown after their first dynamiting, approximately 10 years later.

2. Twenty-one wells have been dynamited the second time, and the increase in specific capacity based on tests before and after dynamiting was 130 per cent, or practically the same as for the 48 wells dynamited the first time. The specific capacity of the 21 wells dynamited the second time was increased from 2.7 gpm per foot of drawdown before dynamiting to 6.2 gpm per foot of drawdown after dynamiting. Some of these wells yielded more water per foot of drawdown than they did when new, 20 years ago.

3. Only two wells have been dynamited the third time. Before the third dynamiting they had an average yield of 2.3 gpm per foot of drawdown and after dynamiting 3.9 gpm per foot of drawdown, an increase of 70 per cent. The yield per foot of drawdown after the third dynamiting was 66 per cent of their original yield in 1935. It is not felt that the results on two wells are representative of what to expect after the third dynamiting.

TABLE 1

*Cost of Dynamiting and Cleaning Ten Wells at Lansing, Mich.**

Labor	$10,385.01
Material	2,324.81
Equipment rental †	5,014.35
Miscellaneous	147.31
Total	$17,871.48
Average per well	$ 1,787.15
Cost per million gallons of increased yield	$ 8,510.22

* For the period 1955–56.
† Accounting department charge for city-owned well rig and trucks.

4. The most recent costs on dynamiting are summarized in Table 1 for ten wells dynamited and cleaned during 1955 and 1956. The costs include installing and pulling the cleanout pump and the cost of pulling the permanent pump. Cost of reinstalling the permanent pump is charged against pump maintenance.

The cost of $8,510.22 per million gallons of increased yield obtained by dynamiting is only 14 per cent of the cost of a new well extension. During

1955–56 4 new wells were drilled and equipped at a cost of $118,321.10, including the necessary water transmission main. A yield of 2.0 mgd was obtained at a cost of $59,160.55 per million gallons.

Conclusions

As a result of 30 years of experience with various methods of well maintenance in Lansing it has been concluded that dynamiting, as outlined above, is by far the best way to control decline in yield caused by plugging of a well. It is felt that 10-lb shots at 5-ft intervals do a better job than 100-lb shots at greater spacing. Five-pound shots have not been tried, except near the water surface in order to stop water from blowing out the top of the well when working in the permanent-type well house. It is possible that 5-lb shots used the entire depth of the well may give as good results as have been obtained using 10-lb shots. Pumpage and water level graphs for several of the wells treated are shown in Fig. 2 and 3.

It should be kept in mind that the results of the various methods of well maintenance described above represent the experience at Lansing, and, although some of the methods tried may not have been successful in Lansing, they may give better results elsewhere under different circumstances.

Correction

The paper "Use of Activated Silica in Water for Textile Finishing," by Frederic A. Prisley (April 1957 JOURNAL, Vol. 49, pp. 459–463) contained an error. In the footnote on p. 461, the term "WT Silicator" should read "WT Silactor."

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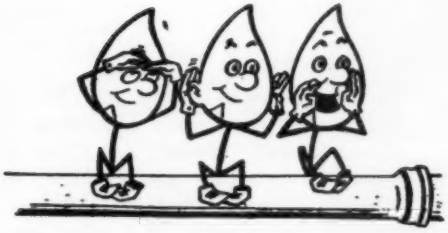


Percolation and Runoff

Over another top went AWWA last month at Atlantic City—over the 3,000 mark in registration, that is, topping its previous record by almost 500. And tops was the word for the Atlantic City meeting throughout—a top technical program topped by the largest exhibit ever, top talent in the entertainment, and a week of weather that was as close to tops for a convention as AWWA ever had. With the first-rate technical program set long in advance and with forewarning of the size of the exhibit and the quality of the entertainment, it was registration that provided the big surprise, running 267 higher than the most optimistic of 72 guesses made by the Board of Directors and their wives in January. A look at the statistics presented in the table on page 42 P&R will give an idea of just how rapid has been the growth of conference attendance since 1950–54, when reaching the 2,000 mark was a matter of touch and usually no go.

Not just quantity, but quality was tops in all elements of the program. Thus, the 125 scheduled participants in the 15 technical sessions provided more and more interesting information on what is new in the water works field than ever before, featured by such sessions of special interest as that covering saline-water conversion, reservoir evaporation control, and cloud seeding, that on statewide water development which included an address by New Jersey's Governor Meyner, that on fluoride application under John Baylis' firm hand, and that on water utility earnings under the guidance of Louis Howson. Beginning at an open house on Sunday and all through the week on their way to and from meetings, those in attendance spent many mouth-watering hours trying to see all 20,000 sq ft of the latest and best in water works equipment and services set up in a record 197 booths by a record 101 manufacturer members of AWWA. And what began in formal technical sessions or in examination of exhibits often continued far, far beyond closing time—sometimes in official committee meetings, but more often over something stronger than water in one of the hospitality rooms that made all of AWWA welcome in all eight official hotels.

But all wasn't shop talk and work; Atlantic City's evenings, after a hot salt water bath in one of those high-sided tubs, were just made for relaxing and enjoying. Thus, the fun got under way early at the Boardwalk Buffet on Sunday evening and continued through the week. Having become acquainted and reacquainted in the get-together that followed the Sunday eating, AWWAers joined in paying tribute to this year's honors earners on Monday—to new Honorary Members Bert Berry, Charlie Capen, Logan Kerr, and W. A. Kunigk; to Diven Medalist John Murdoch; to Goodell

(Continued on page 40 P&R)

(*Continued from page 39 P&R*)

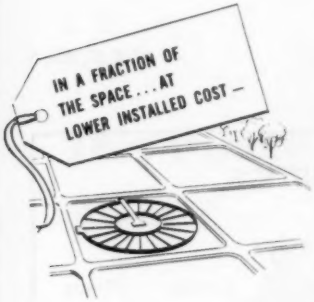
Prizewinner "Lars" Larson; to Division Awardees Jack MacKay, Louis Howson, John Baylis, and Professors Warren Kaufman and Gerald Orlob; to Harry E. Jordan Scholarship Awardees Herbert Hassis of Clarkson College and Wilbert Schlimmeyer of Rutgers University; and, finally, to 25 new winners of the George Warren Fuller Award. Serenaded by the Rutgers University Glee Club, AWWA's Men of the Year were guests of honor at the President's Reception and Dance which followed the ceremony.

For at least 150 strong—more than 20 of them ladies—Tuesday's relaxing started at 8:30 AM at the first tee of the Sea View Country Club in neighboring Absecon, where Tom Coleman of Summit, N.J., emerged as operator's low grosser with an 82, Lou Seton of Lock Joint Pipe Co. peddler champ with an 80, and Carolyn Von Hartz Lock-Jointer lady low grosser with a score that the men have refused to reveal. Then on Tuesday evening, Ray Middleton of *Annie Get Your Gun* and *South Pacific* fame was on hand with a troupe and a program of Victor Herbert, Stephen Foster, and Sigmund Romberg to make everyone—including the golfers—forget everything but music. And on Wednesday, AWWA was on the town with an evening free for its own arranging, for Hackney's, for the Bishop's Savoy, for the Million Dollar Pier, for parties, for Boardwalking under the May moon, or even for some sleep. It was Thursday evening, though, that capped the climax, when 1,200 members and guests turned out for the banquet and ball to do honor to Bill Brush upon his retirement after 35 years as an AWWA officer, as well as to Paul Weir and Fred Merryfield in retiring from and taking over AWWA's presidency. Opening with the presentation of orchid leis from Hawaii to the officers and their ladies by Edward J. Morgan of Honolulu and "Uncle" Bill Chun of Hilo, the program was featured by Malcolm Pirnie's tribute to Bill Brush and his presentation of a silver tray containing the facsimile signatures of the 21 living past-presidents with whom Bill has served. It was after the eating and before the dancing, too, that the Indiana Section took possession of the Hill Cup, the Cuban Section held on to the Henshaw Cup, and the California Section prolonged its hold on the Old Oaken Bucket, and that Fred Merryfield, whose voice had earlier been limbered up in a duet or two with Treasurer Bill Orchard, made his inaugural address a short, sweet, and meaty review of the problems that face the water works field and the ways to their solution.

Honored not only at the dinner, but all week, were convention committee chairman Les Hart, ladies chairman Louise Mann, and the hundreds of New Jersey and Pennsylvania members who shared the burden of hosting this biggest of all AWWA conventions. Les, Lew Klockner, Charlie Alfke, Hubert O'Brien, Harvey Howe, Sid Wilson, Bill Reinicker, and Harold Ohland headed up the various local male committees. Meanwhile, helping Louise to lead the ladies—all 669 of them—a life of teas, cards, lunches, and tours were the Missuses F. G. Merckel, C. G. Bourgin, P. S. Wilson, J. A. Frank, and a host of other hostesses.

The bigger they are the better they are it seems—and this was the BIGGEST by far. But wait till next year, say our Southwest friends—Texas being what BIG means, Dallas promises to overtop even this. Better—no, Best—be there to see that—next Apr. 20–25—y'all!

(*Continued on page 44 P&R*)



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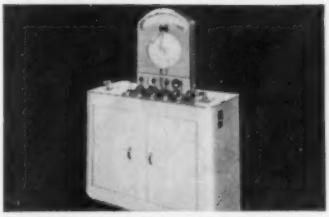

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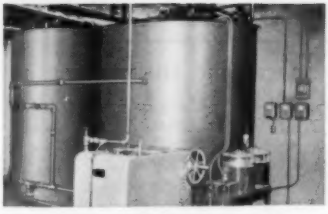

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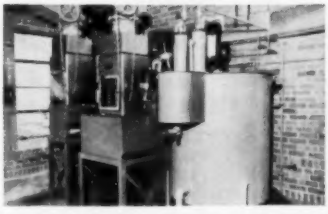

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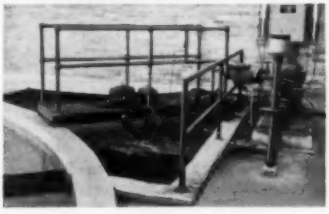

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1957 CONFERENCE STATISTICS

(See story on p. 39 P&R)

Atlantic City Registration by Days

Day	Men	Ladies	Total
Sunday, May 12	1,179	401	1,580
Monday, May 13	775	247	1,022
Tuesday, May 14	230	21	251
Wednesday, May 15	157	—	157
Thursday, May 16	57	—	57
TOTALS	**2,398**	**669**	**3,067**

Geographic Distribution of Registrants

UNITED STATES & TERRITORIES

Alabama	28	Maryland	77	Tennessee	37
Arizona	9	Massachusetts	83	Texas	58
Arkansas	5	Michigan	98	Utah	5
California	103	Minnesota	21	Virginia	55
Colorado	28	Mississippi	7	Washington	15
Connecticut	45	Missouri	67	West Virginia	21
Delaware	13	Montana	3	Wisconsin	37
Dist. Columbia	38	Nebraska	15		
Florida	30	New Hampshire	3	**CANADA**	
Georgia	41	New Jersey	354	Manitoba	1
Hawaii	2	New Mexico	1	Ontario	77
Illinois	177	New York	498	Quebec	9
Indiana	80	North Carolina	39		
Iowa	46	North Dakota	4	**FOREIGN**	
Kansas	27	Ohio	171	Asia	7
Kentucky	25	Oklahoma	5	Europe	4
Louisiana	27	Oregon	8	Latin America	9
Maine	7	Pennsylvania	495		
		Puerto Rico	6	**TOTAL**	**3,067**
		Rhode Island	28		
		South Carolina	18		

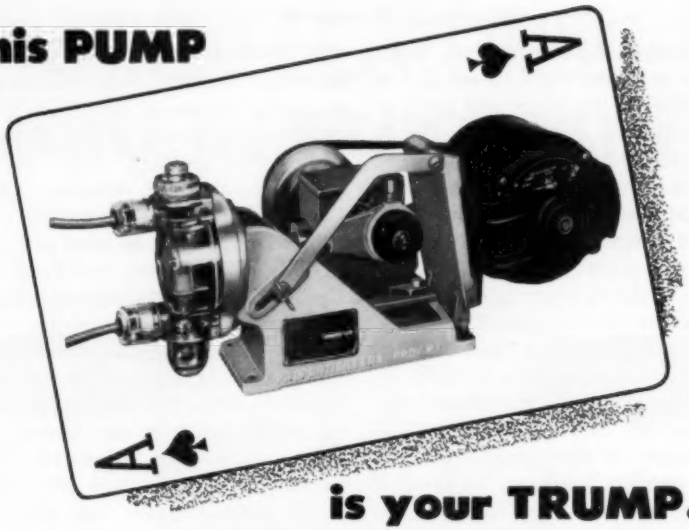
Comparative Registration Totals—1948–1957

Year	Place	Men	Ladies	Total
1957	Atlantic City	2,398	669	3,067
1956	St. Louis	2,026	510	2,536
1955	Chicago	2,075	512	2,587
1954	Seattle	1,536	527	2,063
1953	Grand Rapids	1,532	365	1,897
1952	Kansas City	1,600	386	1,986
1951	Miami	1,415	491	1,906
1950	Philadelphia	1,678	329	2,007
1949	Chicago	1,593	374	1,967
1948	Atlantic City	1,348	356	1,704

Win, Place & Show in Section Awards

Henshaw Cup		Hill Cup		Old Oaken Bucket	
Cuban	**84.6%**	**Indiana**	**48.37**	**California**	**1,349**
Rocky Mountain	82.9%	Iowa	24.44	Southwest	1,058
Montana	64.8%	Nebraska	23.55	New York	834

This PUMP



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METERS FEEDERS CONTROLS

(Continued from page 40 P&R)

The Atomic Age is not only upon us, it has us down—and, if we are to believe Albert Schweitzer and some of the distinguished people who do, it threatens to get all mankind down and, at least on its way, out. When atomic fission first mushroomed into our lives, it was the danger of having our whole world blow up that was most distressing; now, a dozen years later, we find that it is not the external explosions, but the internal ones that most threaten us—the genetic mutations brought on by increased exposure to radioactivity. Mutations can, of course, bring about improvement in the species, but the kind of changes indicated as possible by our biologists are hardly something to look forward to.

What has been most effective in keeping us down, though, has not been the monstrousness of the predictions or even the fact that they have been made by respected authorities on the subject, but our own profound ignorance of the basic concepts involved. We get a little idea of what radioactivity as an accomplished fact means to us in the water works field by reading such articles as the three contributions from the recent EJC Nuclear Congress which appear in this issue (pp. 743–71),* but we wonder if we shouldn't be stepping in before the fact. Abel Wolman gave us a good picture of how much like getting rid of flypaper is the disposal of radioactive "garbage" (May JOURNAL, p. 505), and we wonder why the "stuff" can't be reconstituted into something at least as inert as uranium ore. Perhaps if we had been one of the 12,000 scientists and engineers who were afforded a first opportunity to see an operating nuclear reactor at the Congress last month (see cover picture) or, better yet, one of the 200 who sat at its controls, our understanding might have been improved, but we doubt even that. And with our authors getting down into the minute details of handling radioactive wastes, and with nuclear reactors, such as the one demonstrated, already being mass-produced by Aerojet-General Nucleonics of San Ramon, Calif., we feel more than a little archaic.

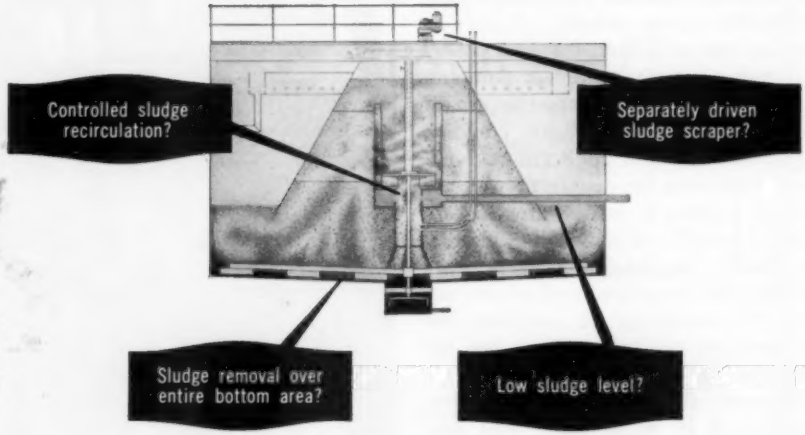
Our out, of course, is to trust the experts and take it from where we can understand. And until the experts themselves agree, we will be much happier to trust the optimistic ones. Thus, we can continue to read and report such items as the good news that radioactivated water has been successfully decontaminated at Oak Ridge by the use of shale, followed by long-chain polyelectrolyte coagulation and then settling and filtration, and not concern ourself about the 1 to 5 per cent of radioactivity left or the possible effects of the polyelectrolytes. And we can pass along the word from the recent AEC hearings on atomic liability insurance that:

> Probabilities of accidents occurring were projected to the time when 100 large power reactors are operating in the US. Even the most pessimistic of these esti-

* Readers may also be interested in the following papers presented at the EJC Congress but not scheduled for publication in the JOURNAL: 57-NESC-17—"The Application of Radioisotopes to the Measurement of Soil Moisture Content and Density," by Paul F. Carlton; 57-NESC-1—"Atomic Waste Disposal by Injection Into Aquifers," by E. Roedder; and 57-NESC-92—"Problems Facing State Agencies in Handling Treatment and Disposal of Radioactive Wastes," by Emil C. Jensen, E. F. Eldridge, C. M. Everts Jr., and H. C. Clare. Copies of these papers may be obtained for 30 cents each from ASME Order Dept., 29 W. 39th St., New York 18, N.Y. (order by paper number only).

(Continued on page 46 P&R)

WHICH FEATURES...
ASSURE THE CLEAREST WATER?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(Continued from page 44 P&R)

mates works out to less than one chance in 50,000,000 of a person being killed in any year in a reactor accident. Currently the chances of getting killed in an auto accident in any year are quoted at one in 5,000.

without getting too persnickety about the difference between 100 reactors and 65,000,000 motor vehicles. It isn't as grim as that, of course, for such potential goods as atomic power for pumping and sea water conversion, the use of isotopes for rapid tests for coliform organisms, and the application of fission products to the disinfection of water and wastes, as well as the already realized benefits of radioactive tracers, can hardly be dismissed. Our only difficulty lies in getting so far over our head in attempting to calculate the risk that we can see nothing but the problems.

However deficient our own understanding of it, we're quite well prepared to admit that the Atomic Age is here to stay. Why let it get us down then? Up and atom!

Henry Wilkens, former district manager of Texas Water Co., Houston, has joined the staff of the consulting firm of Freese, Nichols & Turner, Houston, where his duties will be in the field of municipal engineering.

Carl G. Paulsen has retired as chief hydraulic engineer of the USGS Water Resources Div. His successor is Luna B. Leopold, with Raymond L. Nace designated as assistant chief. Mr. Paulsen will continue to serve as Delaware River Master and will also continue in a special advisory capacity on a number of international water commissions.

A tamperproof nonfenderbender is the new cartridge-shaped hydrant now invading the streets of Philadelphia. The invention of Gerry Arnold, general superintendent of Philadelphia's water department, this less ugly plug is designed to prevent the unauthorized openings that occasionally cut pres-

Gerry Arnold, Plug Along

(Continued on page 48 P&R)

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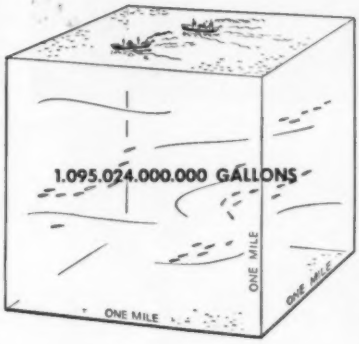

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(Continued from page 46 P&R)

Fender Foe and Friend

sures to the danger point during the hot days of a Philadelphia summer and to keep its "nose" out of the way of curb-hugging cars—for its own, as well as the cars', good. The tamperproofing is accomplished by the use of a recessed cross-headed nut which permits operation only with a special lugged tool carried on water and fire department trucks; the fendertending stems partly from the same recession and partly from the trussed bust line. Made up according to Gerry's ideas and added to its line by Darling Valve & Mfg. Co., the new plug has been received with enthusiasm by all but the SPCA, which apparently fears that its use will set off an epidemic of canine neuroses, if not uremia, and those of the younger set to whom the nearest hydrant had long been a sort of city seashore. As long as there are "old" dogs, though, there will undoubtedly be old-type hydrants within reach; and lest the young boys learn new tricks, there will be supervised spray streets, as much to reduce temptation as temperature. The police department, meanwhile, is preparing itself for a new Philadelphia story: "But, officer, I didn't know it was a hydrant."

The Committee on Large Dams has undertaken the task of assembling and publishing vital data on important dams in the United States. It plans to publish a "Register of Dams in the United States," which will be a valuable reference document containing dam names, dimensions, and other salient facts. The names of the owner of the dam, the engineering firm responsible for its design, and the construction contractor will also be included. This compilation will serve to bring recognition to many designing, engineering, and contracting firms engaged in dam construction.

Height alone will not be the primary consideration in determining whether or not a dam should be included in the register. It is recognized that some dams, while not outstanding in size, incorporate interesting and complicated engineering features, many of which have become prominent through dis-

(Continued on page 50 P&R)

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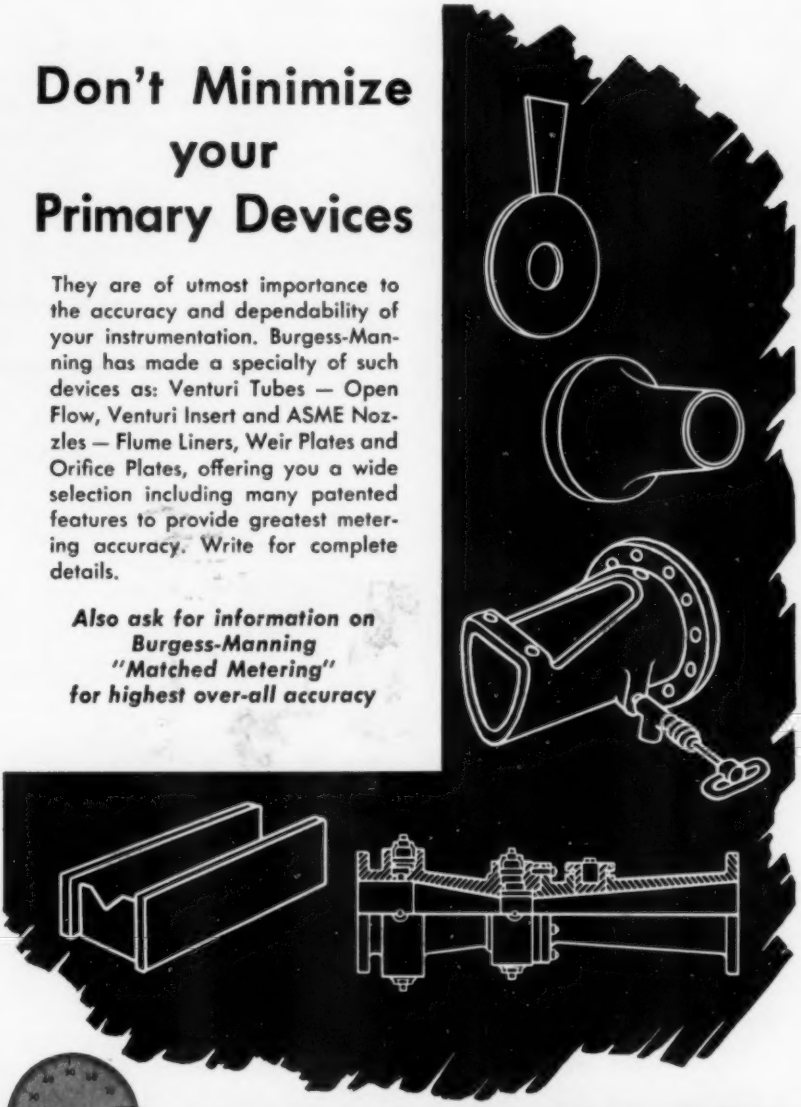

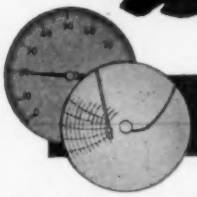

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(Continued from page 48 P&R)

cussions and writeups in technical journals. Dams having a structural height of approximately 50 ft or more could fall in this category. Photographs of the more prominent structures will be included in the register.

Owners, engineering firms, and contractors are urged to cooperate by contributing available data. Necessary forms for recording the data may be obtained from T. W. Mermel, chairman, Committee on the Register of Dams, 4540—43rd St., N.W., Washington 16, D.C.

The US Committee on Large Dams is a member of the World Power Conference' International Commission on Large Dams, which aims at the encouragement of improvement in design, construction, maintenance, and operation of such structures. The US Committee on Large Dams is under the chairmanship of Francis S. Friel, Albright & Friel, Philadelphia.

The 300,000-gal fish tank shown above is only the latest in a series of examples of what can be done with water reservoirs—this one having been designed in the same proportions as a No. 4 can and constructed for Star-Kist Foods, Inc., by Chicago Bridge & Iron Co., which seems to have become expert at tin can types (see January P&R, p. 44). Located at the Terminal Island, Calif., plant of Star-Kist, the can, which is 40½ ft in diameter and 32 ft high, would hold enough tuna fish to make chicken salad for the whole world. But what impresses us most is the possibility it suggests for augmenting water works income by selling advertising space on such structures. And if the city fathers or the civic clubs objected to blazoning the advantages of "Doakes Opium" or the "High-Life Club" in 20-ft letters over the center of town, perhaps they could be induced to work for an increase in rates that would make such outside income unnecessary. There is more than one way, in other words, to scale a tuna.

(Continued on page 52 P&R)

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(*Continued from page 50 P&R*)

The Southwest drought is apparently more than over now. We knew it was tough while it lasted, but an AP report out of the area last April really dramatized how serious things got:

LITTLE ROCK, Apr. 6.—Employees in the office of the Little Rock water works here have placed 44 buckets to catch water dripping into a basement vault where records are stored.

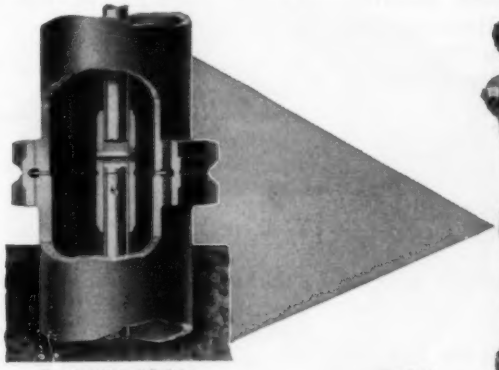
Superintendent Les Jackson really must have been desperate.

ASCE has appointed Hal W. Hunt executive editor of *Civil Engineering*. He succeeds Robert K. Lockwood, who has been promoted to assistant to Executive Secretary William H. Wisely. Mr. Hunt, a former associate editor of *Engineering News-Record*, recently returned from an engineering assignment in Spain.

A BC WC, which proves that modern plumbing is at least 3,000 years old, was recently unearthed by Danish archeologists searching for a royal tomb beneath the ruins of a 16th Century Portuguese fort on the Persian Gulf island of Bahrein. What they found was a throne room of an unexpected type, divided into two sections, each containing two water-flushed toilets. Just what happened to the WC between 1000 BC and the modern days of "modern plumbing" isn't known, but if the cost of plumbing service continues in its present direction at its present rate very long, only a king will be able to afford a four-flusher. The price of running water, meanwhile, continues a bargain, whether for a royal flush or just a straight one.

(*Continued on page 54 P&R*)

Here's How KENNEDY'S Safetop Hydrant Saves Maintenance and Repair Costs . . .



Construction of Safety Breakable Section of KENNEDY SAFETOP Fire Hydrant.

Fig. 1280
KENNEDY SAFETOP
FIRE HYDRANT

A broken KENNEDY SAFETOP . . . and all you need to repair it: When struck a smashing impact and broken, here's how the KENNEDY SAFETOP fire hydrant breaks. A clean break at the Safety Breakable Section means no damage to the main and expensive parts of the hydrant and no loss of water.

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KENNEDY SAFETOP fire hydrants are designed and constructed with these outstanding features: Protection against flooding upon accidental breakage; maximum supply of water at nozzles available from supply main; minimum friction loss from inlet elbow to nozzle outlets; positive, complete drainage after operation to prevent freezing; leakproof valves and gaskets; easy fast inspection and renewal of operating parts.

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(*Continued from page 52 P&R*)

Our Ford foundation of water meter and rhyme seems somehow to have aroused some professional contributions. Thus, with the Beermann and Holmgren paper on San Diego water problems last month (May JOURNAL, p. 525) came this upswell of emotion from H. Austin Adams' *The Story of Water in San Diego:*

The story of Man began at a spring.
It will end when the springs run dry.
The tether of thirst alone
Bound the feet of the otherwise footloose savage.
"No water no life."
This truth Man learned at the Dawn of Things.
The trail to the spring
Was the first of roads.
From Stone Age to Now, Man has trod
No path save the zigzag one from water to water.
Water settled the question
As to where to camp.
And later on, when the idea
"Home" had taken root,
By the side of a well
Was each home built.
About the well sprang the primitive village.
The village in turn grew into the town;
The town again became the city—
But only where water in plenty was to be had.
Only so long as the wells were full.
Thus in all his long upclimb,
From cave to castle, from hut to house,
From animal want to civilized comfort,
Man has ever been guided by thoughts of thirst.
And evermore must water determine
Where and where not Mankind may live.
For the story of Man
Is the story of water.—It will end
When the springs run dry.

And only days later, the not always intelligible W. H. Auden, under virtually the same title as friend John L. Ford (February P&R, p. 36) ended his "First Things First," in the *New Yorker* magazine in this blaze of perspicuity:

So many cubic meters the more in my cistern
Against a leonine summer—putting first things first:
Thousands have lived without love, not one without water.

Well, next time, rhyme!

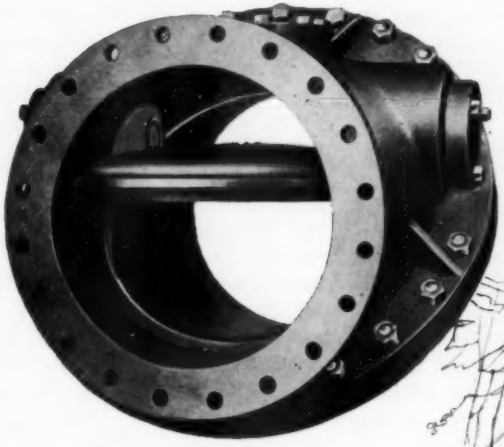
Ernest D. Hawkins has been named superintendent of the Bureau of Water, Knoxville (Tenn.) Utilities Board. He succeeds Cecil E. Eubanks, who has been with the board since 1924. Replacing Mr. Hawkins as head of the board's Water Engineering Dept. is Reeves P. Claxton, formerly assistant engineer.

A revised commercial standard, CS 197–57, has been issued by the US Dept. of Commerce on flexible polyethylene plastic pipe. One of the requirements is that such pipe shall meet the National Sanitation Foundation specifications for suitability as a vehicle for potable water. The standard also contains new dimensional tolerances for ½–6-in. sizes, procedures for bursting and cracking tests, and a section on recommended working pressures. Copies may be obtained for 10 cents each from the US Government Printing Office, Washington 25, D.C.

Water rights—the matter of priority in the use of available water resources—are of most urgent concern to the water industry today. They are a subject in which the legislatures of all 37 "Eastern" states have finally taken an active interest, so that there is hope in the not too distant future of

(*Continued on page 56 P&R*)

First with Floating Power



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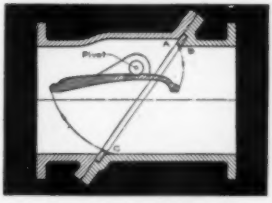
With Chapman's Tilting Disc Check Valve the "Airfoil" disc floats on the flow. When the flow is on, the disc balances perfectly . . . and quietly. There's never a flutter. No vibration. No trouble with head loss or flow resistance. And after the flow subsides the disc automatically drops to a closed position. The closing is fast. The closure is tight. No slamming. No banging. No damage to valve or system. No scraping or wearing of disc and seat. It all adds up to top performance and lowest maintenance and replacement costs even under severe operating conditions.

For handling fluids or gases under a wide range of pressures, always specify Chapman Tilting Disc Check Valves. They're available in iron or steel. Explained in full in our Catalog 30-A. Yours for the asking. Write.



Cross-section of the Chapman Tilting Disc Check Valve illustrating the way that the balanced disc is supported on the pivot, with arrows showing the travel of the disc. A feature of the design is that the disc seat lifts away from the body seat when opening, and drops into contact when closing, with no sliding or wearing of the seats.

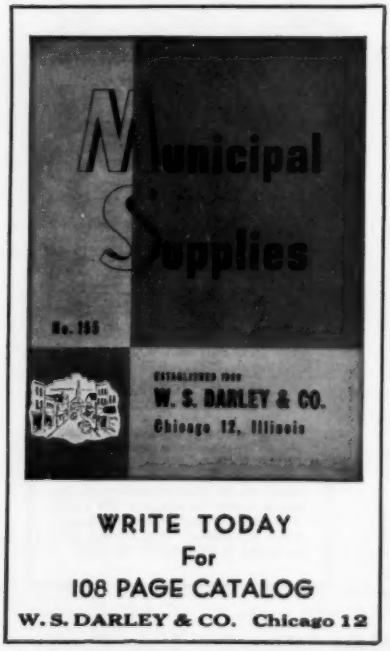
The CHAPMAN Valve Manufacturing Co.

INDIAN ORCHARD, MASSACHUSETTS

(Continued from page 54 P&R)

clarifying the merit of conflicting claims. Meanwhile, as both industrial and public water systems have increased their demands spectacularly enough with the unparalleled rises in production and population, agriculture has been outstripping both with its discovery of the value of supplemental irrigation. And, while public water supply has been standing on the argument that the 150 gpcd it provides is vital to keep the community alive and healthy, industry has been busy pointing out that 165,000 gal of water used in producing a ton of steel is much better spent than 700,000 gal in growing a 500-lb bale of cotton. Agriculture, though, has been anything but idle or unimaginative, improving its position in such dramatic moves as introducing hygiene to the pregnant pig pen. It was at Oklahoma A&M that this latest argument was developed by researchers who proved that expectant sows given shower baths farrowed 2.89 more pigs per litter than did pigs that were pigs. Actually, whether it was the coolness or cleanliness provided by the summer showers that did the trick matters very little; with the price of pork chops these days, industry's advantage in the matter of dollar value per gallon used may have been significantly reduced. All of which does make us wonder, though, whether it is the 2,300,000 bathtubs now produced annually or the 500,000 home air conditioners that are responsible for the record of more than 4,000,000 babies last year. Whichever it may be, of course, it's an argument for giving priority to the water rights of public water systems.

(Continued on page 96 P&R)



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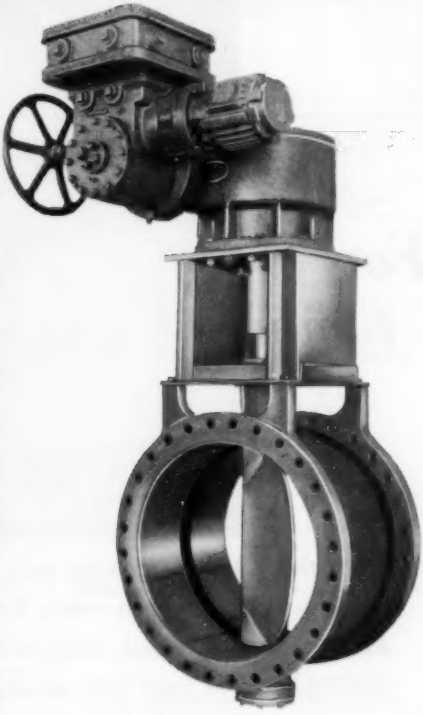

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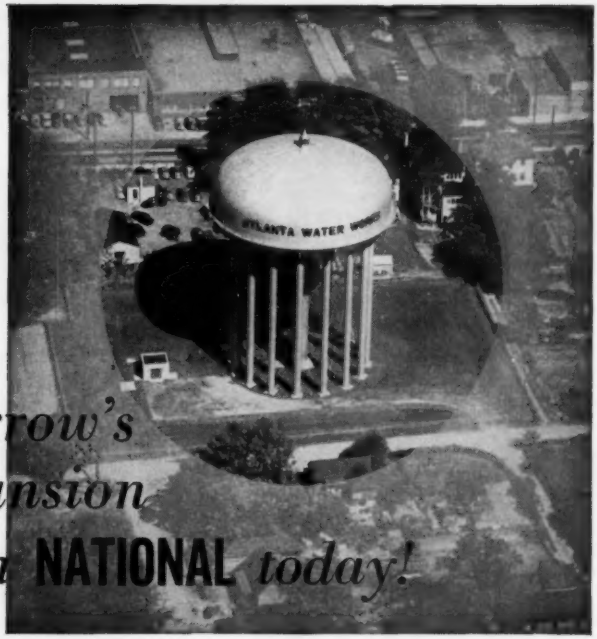

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Key: In the reference to the publication in which the abstracted article appears, **39**:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, **39**:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *BH—Bulletin of Hygiene (Great Britain); CA—Chemical Abstracts; Corr.—Corrosion; IM—Institute of Metals (Great Britain); PHEA—Public Health Engineering Abstracts; SIW—Sewage and Industrial Wastes; WPA—Water Pollution Abstracts (Great Britain).*

BOILERS AND FEEDWATER

The Prevention of Scale and Corrosion in Boilers. P. HAMER. J. Inst. Heating Ventilating Engrs. (London), **23**:476 ('56). Formation of boiler scale is prevented by softening feed water and, when boiler is operated above 200 lb/sq in., addn. of Na phosphate. Corrision of boilers is normally controlled by keeping total alky. at 10-15% of total dissolved solids except at pressures above 200 lb/sq in. when deoxygenation of boiler water is necessary. Caustic cracking of boilers is caused by action of NaOH on steel in high-tensile stress as often exists near rivet holes. Na_2SO_4 or $NaNO_3$ counteracts caustic cracking. Application of water-softening procedures to heating systems is discussed and suggestions are made for protection of idle boilers, prevention of corrosion by condensate, and removal of CO_2. Use of cyclohexylamine and octadecylamine as corrosion inhibitors, O removal, and priming and foaming in boilers are discussed briefly.—*CA*

Field Studies of Preboiler Corrosion in Higher-Pressure Steam Plants. H. A. GRABOWSKI, H. D. ONGMAN, & W. B. WILLSEY. Combustion, **27**:46 ('56). Tests have been carried out on 21 utility unit boiler-turbine combinations during the past 4 yrs. Samples of water were collected at 5 or 6 points (including condenser outlet, boiler feed pump, economizer inlet, etc.) every half hr, with continuous flow of water during entire survey of 4–6 wks. Approx. 700 samples at each location were checked for pH, Fe, and Cu. O and H contents in feedwater were recorded continuously. Following conclusions were drawn: corrosion of Fe and Cu surfaces is minimized if rise in pH value is due entirely to chem. added for alky. Control of corrosion by addn. of volatile alk. chem. is ineffective if large quants. of CO_2 or SO_2 are introduced into portion of cycle. Overall corrosion of system is increased by O, but it is not possible to est. true rate of corrosion of feedwater cycle in presence of larger amts. of O. NH_3 in pH range 8.5–9.5, reduced corrosion of Cu. Corrosion rate of system can only be evaluated from a concd. sampling and anal. scheme at 5–6 points in cycle. Samples taken simultaneously, under controlled conditions, over 24-hr run yield more reliable trend than that obtained from single weekly anal. over several mos. Samples taken for evidence of corrosion should be collected under acid soln. Amines possess filming properties, and pH cells must be cleaned frequently to obtain true values. Corrosion rate of Cu and Fe surfaces can be reduced to less than 0.01 ppm (in water) if proper pH value is maintained and quant. of O, CO_2, and SO_2 are kept to low value. This is possible in system where makeup is treated to reduce corrosive components and added directly to deaerating heater or condenser. Low-pressure heater drips should be deaerated before adding to condensate system.—*CA*

Development and Present Condition of the Treatment of Boiler Feed Water and Cooling Water. H. STACH. Braunkohle, Warme u. Energie (Ger.), **6**:306 ('54). Author deals with development of processes for treatment of boiler feed and cooling water, describing earlier pptn. processes, their replacement by softening with ion-exchange materials, and modern method of removal of salts with org. exchange materials. Advantages of new org. exchange materials are increased capac. and increased resistance to temperature, acids, and alkalies. Account is given of action of various types of exchange material and of complete removal of salts and silica. Costs are compared with those of evapn. Process can be improved by removal of carbonate hardness by Wirbos process. Other subjects dealt with include removal of oil, incrustations on turbines and

(*Continued on page 68 P&R*)

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(*Continued from page 66 P&R*)

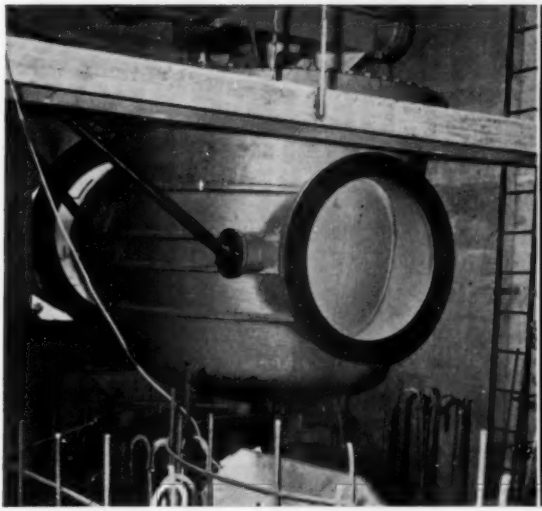
superheaters, and removal of gases. Use of exchange materials (redoxites) for removal of oxygen is important new development.—*WPA*

Control of Resinous Materials in Lower-Pressure Boiler Feed Waters. W. L. ANDREWS. Proc. Ann. Water Conf., Engrs. Soc. West. Pa., **13**:113 ('52). Some failures in steam locomotive boilers in Ontario were found to be caused by presence in feed water of org. compds., such as terpenes, resulting from contmn. of water during passage through areas planted with conifers. Satisfactory control has been obtained by addn. of $NaNO_3$ to oxidize org. compds.—*CA*

Copper Corrosion in Steam Power Houses. II. Reaction Possibilities and Reactions of Copper and Its Oxides in Boilers. W. FUCHS & R. GRASER. Mitt. Ver. Grosskesselbesitzer, **40**:26 ('56). Corrosion has frequently been observed at transition point on Benson boilers, especially on fire side. Corrosion products contain up to 30% Cu as metal and in form of oxides. Expts. have shown that when a mixt. of molecular proportions of Fe_3O_4 and CuO are heated in stream of O-free N, Fe_3O_4 is partially converted into Fe_2O_3 with reduction of part of CuO; this reduction increases with increasing density of packing of mixt. At 400° 2.4% of CuO in loose powder was reduced to Cu, and with pressed pellets 8.2%; at 500° corresponding conversions were 9.3 and 13.3%. Cause of corrosion in boilers is apparently replacement of adherent Fe_3O_4 with loose Fe_2O_3 in presence of copper oxides; Fe is corroded by H_2O under loose Fe_2O_3. EVANS and WANKLYN theory as to initial reaction of steam and Fe to form $Fe(OH)_2$ and conversion of this to Fe_3O_4 in presence of metallic Cu may not be only explanation of this conversion; conversion in presence of metallic Fe may be as rapid.—*CA*

Corrosion Protection in Chemical Water Purification Plants of Electrical Power Stations. H. FURTUNESCU. Energet. si Hidrotehn. (Rum.), **3**:306 ('55). Chem. purif. based on cation exchangers replaced nearly completely previously used evaporators for boiler feed water in elec. central stations. Internal metallic surface of these

(*Continued on page 72 P&R*)



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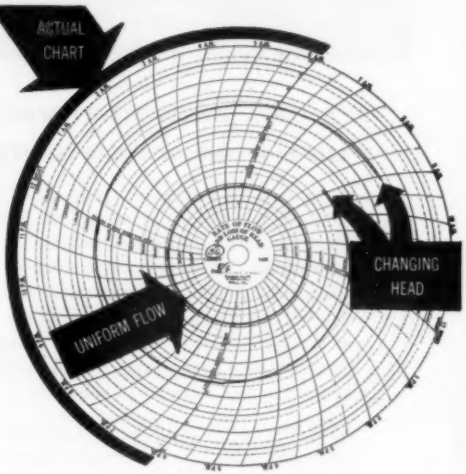
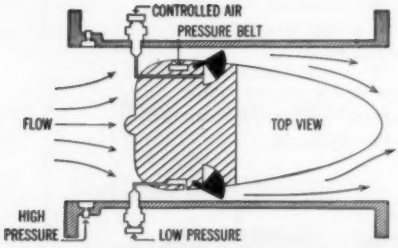
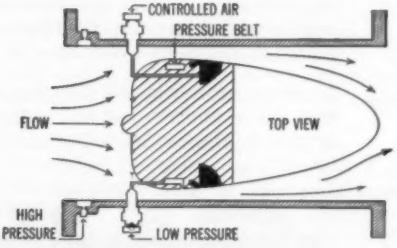


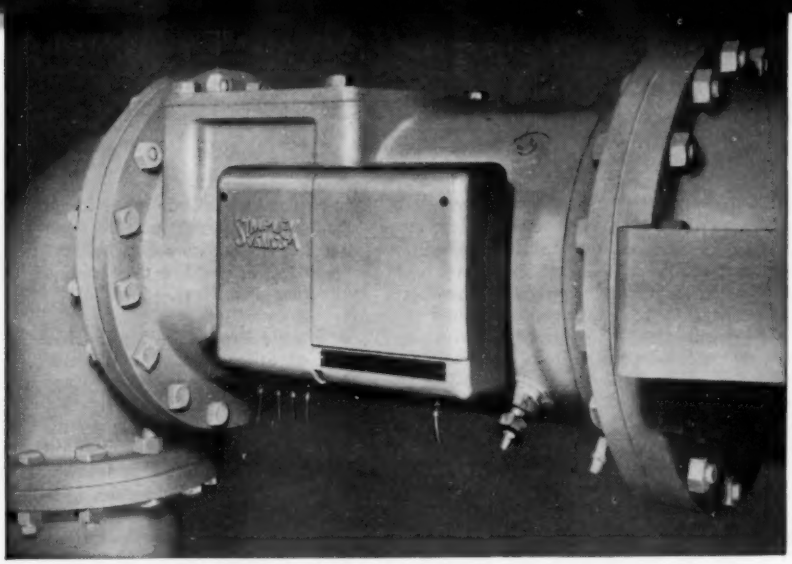
Here's proof that the new Simplex Modulair Filter Rate Controller responds instantly to changes in filter head, holds flow at desired rate... automatically! In chart from Modulair installation No. 2, head changes from 4′ to 7′ while rate forms almost perfect circle at the set 275,000 gpd.



How Modulair works! Pipe-like casting with annular Venturi throat houses streamlined inner body with corded-rubber modulator (black) that expands and retracts pneumatically to control flow. When head is low at start of run, modulator expands automatically to hold flow at set rate.



As filter head loss rises, flow tends to decrease . . . and change the Venturi differential. Sensitive Modulair compensates by instantly retracting the pneumatic modulator, maintaining a constant head-loss value through the combined filter and controller, automatically keeping flow at set rate!



Compact . . . easily installed Modulair is only two to three pipe diameters long! It fits wherever a piece of pipe can fit . . . in any position, horizontal or vertical . . . simplifying pipe gallery layout. High-grade, cast iron Modulair comes in 4" to 24" standard pipe sizes with corrosion-resisting fittings. Cord-inserted rubber throttling element that's as tough as a truck tire has given 30 years' wear in accelerated life-tests.

Accuracy! In 4 years of field performance, Modulair charts show an accuracy in filter control that exceeds today's most exacting demands. This high degree of control extends for wide ranges of head loss and flow rates, including complete, tight shut-off! And there's no drift at end of run.

Longer filter runs! Modulair combines a low head-loss, annular Venturi measuring element with a streamlined throttling element. This new design offers so little resistance to flow that you get longer filter runs, big savings in wash water!

Minimize maintenance! With Modulair's new design, there's no place for air to accumulate . . . no place for sand to lodge and interfere with accuracy. Throttling element, the only moving part inside pipeline, is non-corrosive rubber. Pneumatic poise element is simple, rugged. There are no line valves, no pilot valves, no pistons, no valve shafts, no stuffing boxes to pack!

Lower first cost! Modulair's low head loss means lower operating head requirements . . . permits vertical compression in plant design and lower costs in plant construction.

Completely pneumatic! No intermediate hydraulic steps! No pilot valves! No hydraulic cylinders! Air loading pressure is applied *directly* to the flow controlling element.

Automatic filter operation! Modulair works with control systems of any type to give you remote rate control or master pneumatic control that's fully automatic.

Technical bulletin! For full details on Modulair, write for Bulletin 950. Simplex Valve & Meter Company, Dept. JA-6, 7 East Orange Street, Lancaster, Penna.

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(*Continued from page 68 P&R*)

systems must be protected against attack by acid coagulant and alk. regenerating soln. For this reason, plastic or stainless-steel piping and rubber-coated iron valves are used. Other exposed metallic areas are protected by painting with Pb_3O_4-contg. ground coat and several layers of cover coat contg. vinyl plastic and asbestos. It is expected that 14-layer coat will protect surface 3–5 yrs. —*CA*

Determination of Phosphoric Ion in Boiler Waters. J. HUBIE & H. CHOSSAT. Chaleur Ind., **36**:307 ('55). Some modifications to molybdenum blue colorimetric procedure for phosphate are proposed. Increased accuracy and ease of manipulation are obtained by controlling pH closely. pH of 0.7 ± 0.1 provides max. color development and can be obtained easily by adding sufficient 0.1*N* HCl to decolorized phenolphthalein. Subsequent treatment: add 1 ml reagent (756 mg $(NH_4)_6Mo_7O_{24}$/100 ml 3*N* H_2SO_4) and 1 ml $SnCl_2$ to give desired pH. Single standard PO_4 soln. of 5 mg $(NH_4)_2HPO_4$/l is used. Color intensity measurements are made with comparator and results are computed on basis of calibration curve. As animal or vegetable C is unsuited for decolorizing of boiler water owing to their PO_4 content, evapn. with H_2SO_4 is found satisfactory.—*CA*

Boiler Tube Deposit Composition and Thickness. R. T. HANLON. Modern Power and Eng. (Can.), **51**:74 ('57). Photomicrographs are given of various types of boiler scale as they appear on surface of internally heated tube from an exptl. boiler. Analcite, Fe_3O_4, and Mg phosphate deposits are among densest and show greatest reduction in heat transfer. Mg phosphate deposits may be prevented by use of lignin derivatives, and, in extreme cases, addnl. use of silicates. Fe pickup can be prevented by use of suitable volatile amines or some of newer filming compds.—*CA*

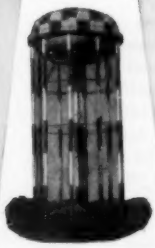
Chemical Cleaning of Locomotive Boilers With Molasses as the Inhibiting Agent. E. T. RELF. Proc. 23rd Conf. Queensland Soc. Sugar Cane Technol. (Austral.), p. 91 ('56). Addn. of molasses to HCl solns. used in removing boiler scale greatly reduced attack on metal. In lab. tests a 5% acid soln. caused metal wt. loss of 2.9% in 24 hr; same soln. contg. 10% molasses caused only 0.2% decrease in wt. of metal. Acid solns. contg. molasses were effective when tried on locomotive boilers, and temps. up to 160°F. could be used without adversely affecting metal loss.—*CA*

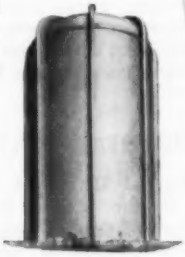
A Simple Procedure for the Internal Control of Silica in Boiler Waters. G. V. L. N. MURTY & U. APPA ROA. Eng. and Boiler House Rev., **72**:15 ('57). Deposition of silica scale in boilers can be minimized by making regular comparison of ratio of silica in boiler water; silica in feedwater as compared with ratio of chlorides in boiler water, and chlorides in feedwater. When silica ratio is less than chloride ratio, silica scales have probably been deposited. Existing methods for detg. sol. silica are not very convenient for routine work. Preliminary investigations indicated that molybdenum blue method was capable of adoption with suitable modifications in reagent concn. Final color estn. could be conveniently made in a Dubosq-type colorimeter by comparison with similarly treated standard silicate solns., or read off from specially constructed calibration curves employing a Spekker photoelectric absorptiometer or turbidimeter.—*CA*

Sealing Coatings for Steam Boilers. D. B. GINZBURG & M. A. MATVEEV. Elek. Stantsii (USSR), **26**:20 ('55). For severe operating conditions, compn. asbestos 20, sand 40, marshallite 20, coal-tar pitch 15, and water glass 5% is recommended. Also recommended is compn. caustic magnesite 45, marshallite 20, asbestos 20, and coal-tar pitch 15%.—*CA*

Oxygen Removal From Boiler Feed Water by Steel Shavings. A. P. MAMET & V. V. GLUSHENKO. Elek. Stantsii (USSR), **21**:19 ('50). Shavings of ordinary C steel, 0.5–0.6 Mn, were used. Basic factors are temp., O_2 concn., contact time of water with shavings, hardness (Ca and Mg bicarbonates). At initial temp. of 70° or higher, water is completely deoxidized with 0.5–1 min. contact, independent of water compn. and O_2 content in range of 0.05–5 mg/l. Steel shavings do not deoxidize cold water, even with 3 min. contact and longer. On filtering soft water, however, there is complete O_2 binding, even at low temp. (30°), contact time 1–1.5 min. Rust formed during deoxidation of softened water did not cause

(*Continued on page 74 P&R*)





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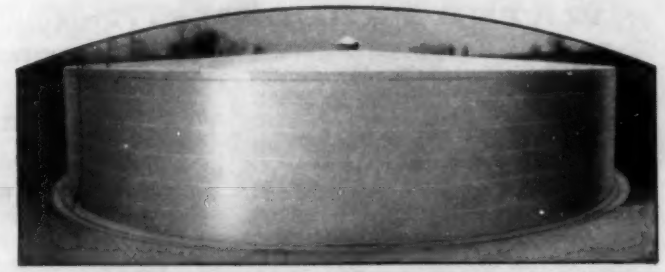

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(*Continued from page 72 P&R*)

passivation of shavings, nor increased hydraulic resistance of filter. Filtrate remained clear and rust remained in filter. Dissolved Fe on 2–3 min. contact was negligible and deposited less than 0.1 mg/l. Steel shaving filter can be used successfully as follows: to remove O_2 passage into medium and high-pressure boiler feed water after thermal deaeration, and to deoxygenate low-pressure boiler feed water, and subfeedwater of heating system. O_2 removal from water with steel shavings may be 6–7 times cheaper than sulfitization, with assurance of trapping any O_2 which gets through. Filter care consists of testing filtrate for O_2 content and iron oxide accumulation at least once every 24 hr, reverse water flush to diminish water pressure loss when removing accumulated rust, and periodic change of steel shavings. Latter is cleaned and defatted beforehand by hot alkali wash followed by hot water.—*CA*

Hydrogen Measurements in Benson and Natural Circulation Boilers. H. KIEKENBERG. Mitt. Ver. Grosskesselbesitz., p. 533 ('53). Measurements were made of H present during daily starting and shutdown of Benson boilers, several instances of boiler corrosion due to steam dissociation having been observed. Shutdown procedure was varied, and H was found to develop only when boiler was shut down under high pressure (without circulation), this causing heat stored in setting to give rise to local hot-spots and steam dissociation. Instrument was designed, based on expansion of steam, to give continuous indication of minute quants. of circulating H arising from Fe-steam reaction, within limits of 1–2 γ/kg steam. Measurements were also made on KSG boilers, and conclusions drawn regarding shutdown procedure are briefly outlined. —*CA*

INDUSTRIAL WATER USE

The Industrial Utility of Public Water Supplies in the United States. Pt. 2; States West of the Mississippi River. E. W. LOHR & S. K. LOVE. US Geol. Survey

(*Continued on page 76 P&R*)

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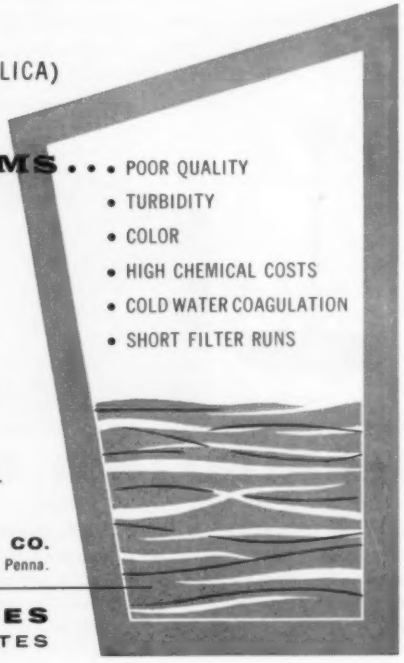
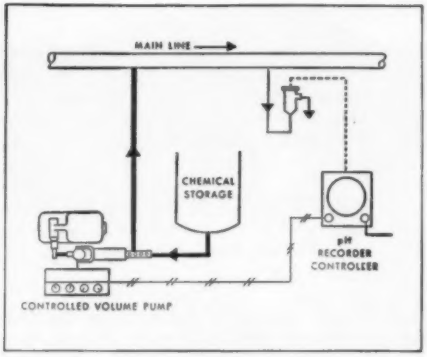
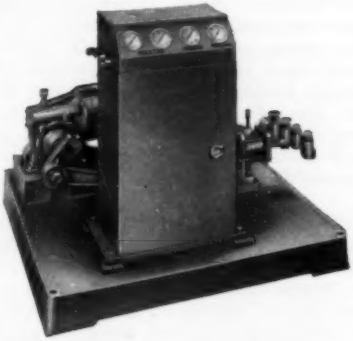




Variable stroke Controlled Volume Pump in a simple pH control system.



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(*Continued from page 74 P&R*)

Water Supply Paper No. 1300 ('54). Discussions on various aspects of water supply, methods of treatment, and quality requirements of water for domestic and industrial uses precede presentation of data on public water supplies of 416 communities in states west of Mississippi R. Information given for each community includes ownership of supply, source, and yield of raw water, treatment given and capac. of treatment plant, storage facilities for raw and treated water, and physical and chemical anals. of raw and treated water. Report is intended as guide to availability and suitability of public water supplies for use by industry.—*WPA*

Industrial Water Supplies of the United States. S. K. Love. Proc. 15th Ann. Water Conf., Engrs. Soc. West Pa., p. 1 ('54). In general account of availability of water supplies for industry in USA, greater part of which is drawn from municipal supplies, avg. annual pptn. and runoff over whole country, surface and ground water resources and qualities of these waters are reviewed. Quant. and qual. of water requirements for industrial purposes are discussed together with extent to which water may be reused in general and by individual industries. Current research on demineralization of saline waters is described, particularly in connection with any increase likely to be shown in availability of water supplies.—*WPA*

A Symposium on Reuse of Water by Industry. Reuse of Steam Condensate as Boiler Feedwater. D. E. Noll & H. M. Rivers. Ind. Eng. Chem., **48**:2146 ('56). Review of corrosion and contamn. problems. **Conservation of Water in the Pulp and Paper Industry Through Recycle, Reuse, and Reclamation.** H. B. Brown. Review. **Recirculation of Cooling Water in Petroleum Refining.** A. J. Brandel. Discussion of corrosion and scaling problems and biol. growths, with particular reference to El Segundo Refinery of Standard Oil Co. of Calif. **Reuse of Cooling Water in an Atomic Energy Commission Installation.** A. L. Biladeau. Primary cooling water is continuously reused because of cost of demineralized water. Cation resins are used to remove any particles which water may pick up by soln., disassociation, erosion, or corrosion, and which may become radioactive. Anion-resin bed is also provided to keep pH at 6 to minimize corrosion of Al-clad fuel elements. **Biological Fouling in Recirculating Cooling Water Systems.** J. J. Maguire. Review. **Adaptation of Treated Sewage for Industrial Use.** S. T. Powell. Review.—*CA*

Deionization of Water for Ice Manufacture. W. A. Cunningham & W. C. Mills. Univ. Texas Eng. Research Series No. **46** ('56).—*CA*

Water Supply of Industry in the German Union in 1952. Clodius. Gas u. Wasserfach (Ger.), **96**:750 ('55). Author summarizes information given in Industrial Report of 1953 on water demand of industries in West Germany (with exception of Baden-Wurttemberg and Bavaria) in 1952. Information covers amt. of water used, amt. recirculated within works, sources of supply, and distr. of water for different purposes in works. Results from 28,967 works with 10 or more employees are given and total industrial demand is calculated as 4,600,000,000 cu m. Results are then classified according to type of industry and by districts.—*WPA*

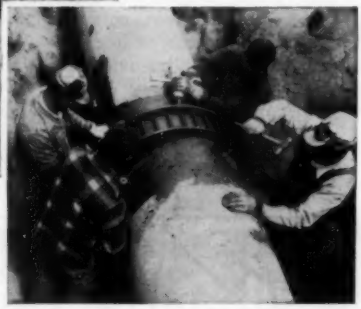
Manual on Industrial Water. ASTM Spec. Tech. Pub. No. 148-A ('54). In 2nd printing of manual on industrial water supplies first published in 1953, chapters are included on uses of water in industry, compn. of water and water-formed deposits, treatment of industrial water supplies, and sampling and anal. of water and water-formed deposits. Detailed procedure given in appendices for sampling and anal. of water and for reporting results of anal.—*WPA*

Water Problems in Power Generation at Supercritical Pressures. E. P. Partridge. Mech. Eng., **77**:883 ('55). Water at high temps. and pressures above critical pressure apparently dissolves many salts, Si, iron oxides, etc., to much greater extent than does steam at temps. below critical pressures and temps. Hence it seems possible that these materials may be deposited at some location in turbine. Problems due to steam blanketing and concg. films will not appear in supercritical boiler. It is also possible that Fe might be carried as Fe_2O_3 in supercritical fluid and converted to Fe_3O_4 at time of deposition, with release of O and corrosion at that point. It is also possible that dissolved solids

(*Continued on page 78 P&R*)

DELIVERING WATER CHEAPER

The high beam strength of steel pipe plus the adaptability of Dresser Couplings makes them the ideal combination for irregular terrain.



Four-man crew using power wrenches assembles this Dresser Coupling in minutes. Dresser Couplings tested bottle-tight on line pressures up to 800 psi.

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For a bottle-tight, trouble-free line that *delivers water cheaper,* it pays to specify steel pipe with Dresser Couplings. Dresser Manufacturing Division, Bradford, Pennsylvania.

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(Continued from page 76 P&R)

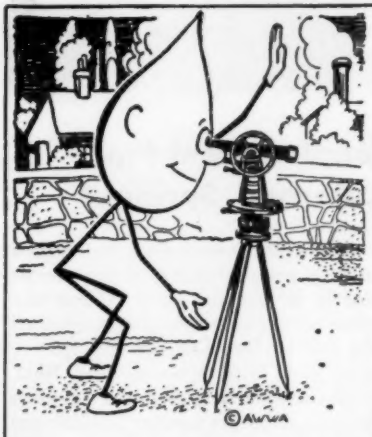
may not deposit in turbines, but might be carried in powder form on into condenser, and again into boiler, where they are redissolved.—*CA*

SOFTENING AND IRON REMOVAL

Experiments on Technical Softening of Water with Ultrasonic Waves. P. MANDY ET AL. Magyar Tech. (Hung.), 7:54 ('52). For expts. on water softening by ultrasonic waves, a Galton tube was used. Length of resonator space, and thus frequency, was adjusted with microscrew. 50 l of water at pressure of 8 atm. were circulated through tube at rate of 40 l per min. Best results were obtained with resonance space length of 15 mm (giving frequency of 17,000 cycles per sec), when in 20 min, with heating to 40°C, hardness was reduced from 24° to 18° (German). Without ultrasonic waves hardness was reduced by only 1.5° at 50°C. With longer irradiation hardness rose again, as calcium and magnesium carbonates were redispersed. From still water after irradiation ppt. formed and after filtration hardness was about 9° less. Softening by ultrasonic waves is thus shown to be not only result of heating.—*WPA*

Iron and Manganese Removal. S. B. APPLEBAUM. Proc. 16th Ann. Water Conf., Engrs. Soc. West. Pa., p. 49 ('55). Troubles caused by presence of iron and manganese in water used for domestic and industrial purposes, and oxidation and ion-exchange methods for removal of these elements from water are outlined. Well waters forming source of supply for Jamaica, N.Y., do not require softening but must be treated to oxidize iron and manganese. This is carried out at one pumping station by aeration, chlorination, sedimentation, and gravity filtration, and at second station by aeration in 2-stage pressure filters, primary coarse filters containing lava, and secondary filters sand. Description is given of pilot scale ex-

(Continued on page 80 P&R)



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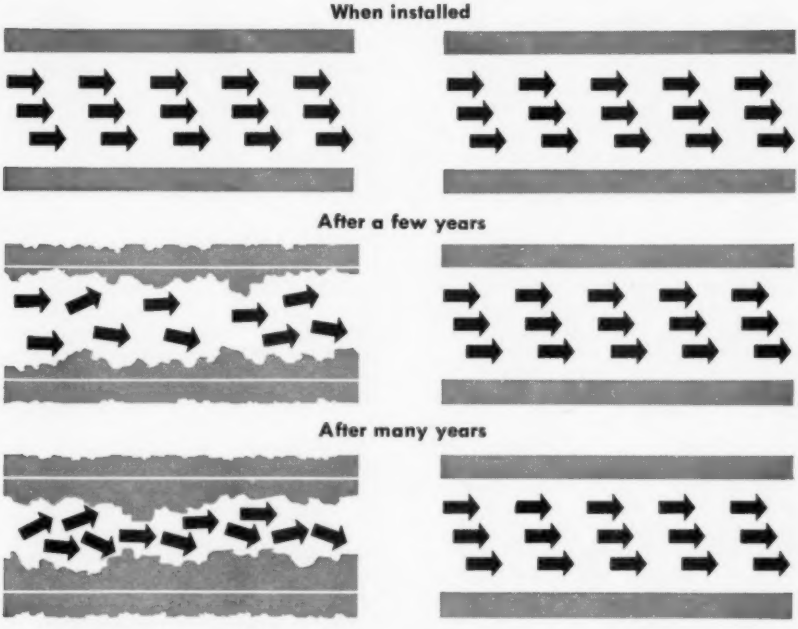

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(*Continued from page 78 P&R*)

periments conducted to obtain information on design of 5-mgd capac. plant for third station receiving combined raw water from 4 wells, total hardness of which was 118 ppm, and concn. of iron and manganese 0.64 ppm and 0.22 ppm, respectively. Effect of results of this investigation upon ultimate choice of equip. and method of treatment is discussed. Provision is made for addn. of lime to prechlorinated water to maintain pH value of 7.5, and aeration and filtration in pressure filters. Data on operation of plant are given.—*WPA*

Systematic Technological Test of Water Purification From Iron. W. Hermanowicz & J. Kelus. Gaz, Woda i Tech. Sanit. (Poland), **29**:70 ('55). Tests are run on samples of 50–100 l obtained for surface waters, directly from spot where water is to be drawn for utilization; for underground wells equipped with pumps, by pumping for 10 min, and then taking sample with rubber hose inserted deep into outlet pipe; and for installations with a const. water flow, with hose immersed in outflowing stream without air penetration into it. Water is passed through sand filter prepd. in glass tube, and iron is detd. colorimetrically in filtered portion. Rapid paper filter may be used instead of sand filter, but test result will depend upon its qual. 6 to 8 l of sample is passed twice through aerator consisting of 2 cylindrical vessels 200 mm high and having 200 holes 1 mm in diam. uniformly distributed in their bottoms. Aerated sample is allowed to stand for 1 hr and then filtered through sand. 3-l samples are treated with increasing amounts of 0.1% $Ca(OH)_2$ soln., and then aerated and filtered. For coagulation, samples of 1 liter are treated with increasing amounts of a soln. contg. 10 mg of $Al_2(SO_4)_3$ per ml and then mechanically stirred, rapidly for the first min, and at 50 rpm for 15 min. After 1 hr they are filtered through rapid filters, and first portions of filtrate are discarded. For coagulation with alkalization, test is run as under above but with prior addn. to samples of fixed amt. of CaO, to obtain proper rate of coagulation and size of ppt.—*CA*

Experiences With Base-Exchange Materials. W. Töller. Mitt. Ver. Grosskesselbesitzer, p. 414 ('51). Drop in capac. of mixed regenerated Permutit softeners was observed when NaCl content of raw water increased sharply. This drop in capac. could be eliminated by use of 30% more NaCl in regeneration. Same behavior was shown by Wofatit C. A mixed Wofatit softener regenerated with 800% NaCl (25–30 g per l of material) showed drop in capac. from 1.35 for raw water at 25° to 0.8 for raw water at 14°. Regeneration with 1,200% NaCl restored capac. to 1.4. At low salt content, vol. capac. of Wofatit C varied sharply with temp.—*CA*

Range of Applicability of Cation-Exchange Processes. J. Leick. Mitt. Ver. Grosskesselbesitzer, p. 389 ('51). In addn. to neutral exchange and complete H neutralization, complete H-exchange softening and H-exchange decarbonization (both with and without simultaneous neutral exchange) are discussed as separate cation-exchange processes. Changes in filter effluent occurring during filtration and regeneration can be explained in terms of variation in charging of individual layers of filter. In case of incomplete regeneration with acid, upper layers are converted largely into H-exchange material, so that during run of filter H ions from this section are carried down, with result that proportion of H-exchange material is increased. Since state of lower layers of filter is primarily responsible for character of effluent, such changes result in change in the alky. of effluent. Decarbonization by H exchange yields an effluent of const. alky. only with exchange material of slight acid strength and with raw water of slight mineral content. In case capac. is incompletely restored by insufficient acid regeneration, such capac. can be best utilized by use of acid-salt-series regeneration with economical consumption of salt, provided temporary carbonate hardness to total hardness ratio does not exceed 0.6. At higher ratio of carbonate to noncarbonate hardness, a second filter must be used.—*CA*

Experiences With Mixed-Bed Deionization of Water. G. P. Monet. Chem. Eng. Progr., **52**:299 ('56). Author reviews various sources of operating difficulty encountered experimentally in purifying feed water and describes modified operating procedure by which these difficulties—namely, lack of pretreatment of feed water and poor regeneration—have been overcome.—*PHEA*

(*Continued on page 81 P&R*)

Craftsmanship...

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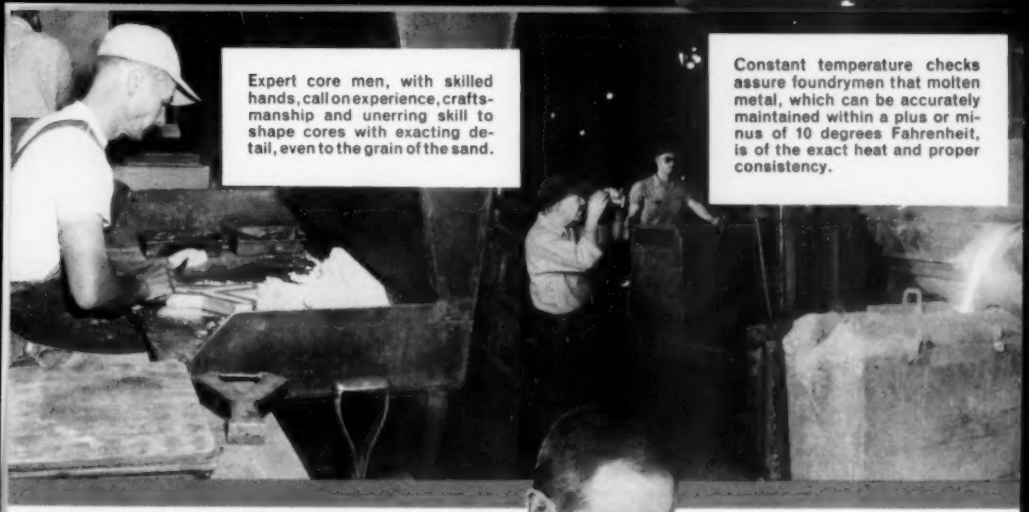
Through a century of service, Mueller Co. has established a tradition of fine craftsmanship, with trained workmen utilizing lengthy experience and expert skills...and with exacting control of quality, materials and manufacturing methods... to produce superior, more dependable products for the nation's essential gas and water industries.



Expert core men, with skilled hands, call on experience, craftsmanship and unerring skill to shape cores with exacting detail, even to the grain of the sand.

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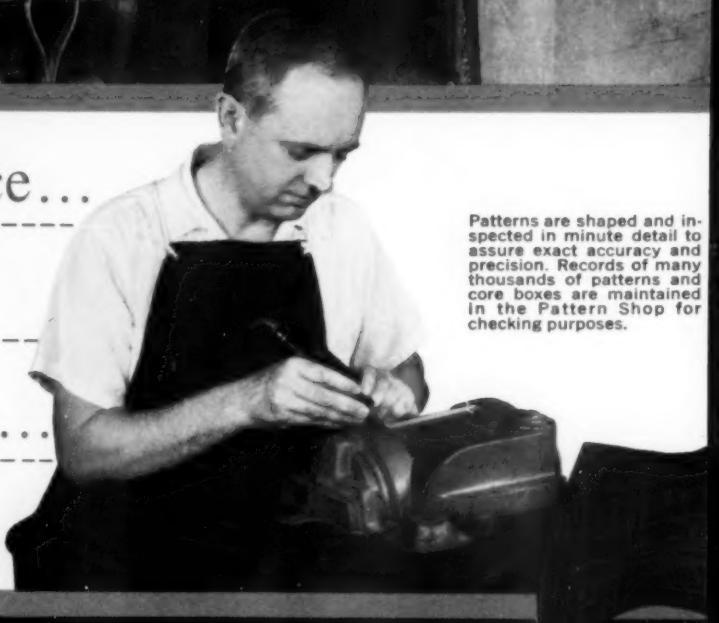
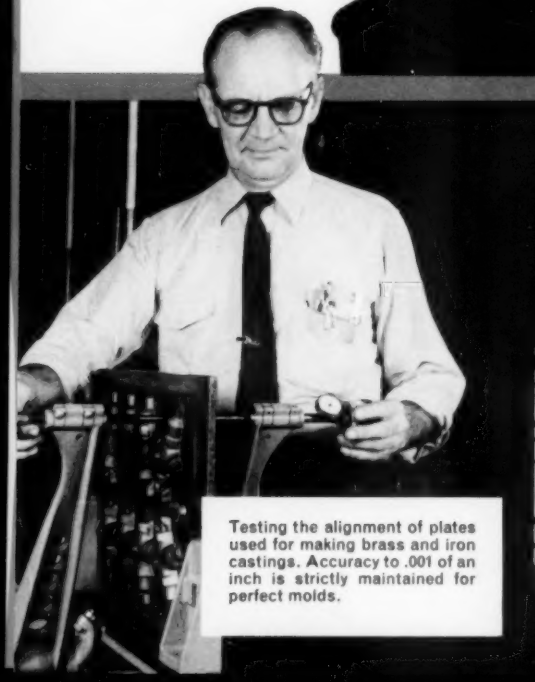
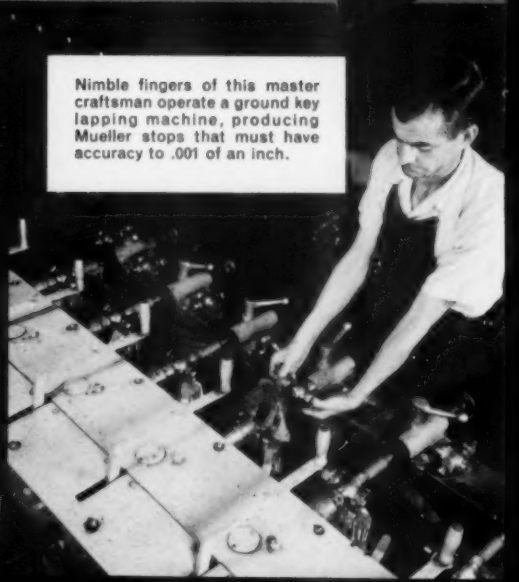


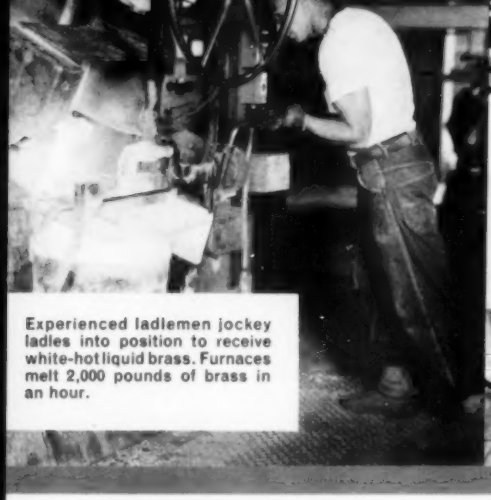
Patterns are shaped and inspected in minute detail to assure exact accuracy and precision. Records of many thousands of patterns and core boxes are maintained in the Pattern Shop for checking purposes.



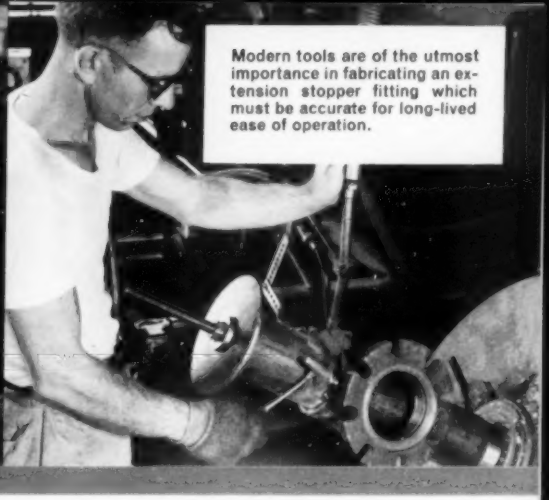
Testing the alignment of plates used for making brass and iron castings. Accuracy to .001 of an inch is strictly maintained for perfect molds.



Nimble fingers of this master craftsman operate a ground key lapping machine, producing Mueller stops that must have accuracy to .001 of an inch.



Experienced ladlemen jockey ladles into position to receive white-hot liquid brass. Furnaces melt 2,000 pounds of brass in an hour.



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(Continued from page 80 P&R)

Algae, Hardness, and Dissolved Solids. D. C. SWIFT. Power, **100**:88 ('56). General discussion of chlorination, softening, distn., and cation-anion exchange, citing fields in which each is most effective.—*PHEA*

Now It's Automatic Demineralizing. R. H. MARKS. Power Eng., **59**:88 ('55). Device is described whereby, through changing conductivities, a demineralizing unit is automatically regenerated when it reaches point of exhaustion.—*CA*

Preparation of a Permutite. B. ZAPIÓR, M. LESZKO & Z. MOSER. Gaz, Woda i Tech. Sanit. (Poland), **30**:381 ('56). Permutite with the following compn.: SiO_2 51.5, Al_2O_3 14.9, Na_2O 9.1, H_2O 25.0%, has been obtained by reaction of Na aluminate and silicate in aq. soln. at 20°. Capac. of ionite is 2.69 milliequivalents/g. It shows good mechanical properties—*CA*

Selection of a Method for Removal of Iron Compounds From the Water of Artesian Wells. V. A. KLYACHKO. Vodosnabzhenie in Sanit. Tekh., No. 8, p. 8 ('56). Removal of iron from artesian water depends upon conversion of ferrous to ferric compds., and complete hydrolysis of latter. This process can be accelerated by catalysts such as freshly pptd. $Fe(OH)_3$, or as sand or sulfonated coal coated with film of Mn oxide. To coat sulfonated coal with Mn oxides, it is first treated with 10% soln. of $MnCl_2$ and then with 1% $KMnO_4$. $Fe(OH)_3$ acts as catalyst only when mixed with Mn oxides. Tests were carried out at pH 5–7. Purifier using Mn oxide-coated sand, crushed pyrolusite, and similar Mn compds. is described.—*CA*

Circulation of Waters in Calcareous Formations and Their Recovery. M. ACHTEN. Tech. Sanit. et Munic. (Fr.), **50**:191 ('55). Survey of the calcareous regions adjacent to north coast of Belgium for waters previously considered nonpotable. Report is based largely on hydraulic and geologic data.—*PHEA*

Desilication of Water by Calcined Dolomites. B. D. BRYANSKII & A. T. DAVYDOV. Elek. Stantsii (USSR), **21**:52 ('50). Dolomites from Donets, Moscow, and Ural regions were examd. Treated according to standard literature, dolomites were used to deoxygenize and desilicate water. With no silt present, 2.7 mg of MgO/mg SiO_2 was used, of calcined dolomite total of 7.4 mg/mg SiO_2. Some dolomite as free CaO interacts with C deposits. Decarbonization process, though consuming calcined dolomite, is more effective than during liming. Pptn. method leads to max. removal of aggressive CO_2; this reduces work of deaerators. High-pressure boiler feed at full capac. with weak mineral water of residual silicic acid content 0.2–0.3 mg/l of SiO_2 does not exceed 10 mg/l SiO_2 in boiler water. Boiler water treatment is limited by total salt content, but not by silicic acid content.—*CA*

Costs of Cation-Exchange Equipment. R. F. PEAK & M. M. DAVID. Chem. Eng. Progr., **53**:37J ('57). Review for chem. engr. for is considering installation of water-softening equip. or who is involved in fixed-bed ion-exchange processes. Data supplied can serve as permanent guide in estg. rough costs and in choice of suitable equip.—*CA*

Iron and Manganese Removal From Municipal and Industrial Water Supplies. V. J. CALISE & R. F. DIETZ. Graver Water Conditioning Co. Tech. Reprint **T-144** ('55). No single method of Fe and Mn removal can be applied in all cases. Anals. are required to det. amt. of Fe and Mn present and forms in which they occur, and it should also be detd. if softening of supply is desirable. There are 7 basic methods of treatment with modifications to meet individual requirements. Methods are: open coke tray aeration, open slat tray aeration, closed forced-draft aeration, solids contact, pressure diffuser, Na zeolite softening and Fe removal, and Fe removal by Mn zeolite. Pilot plant studies are recommended to det. optimum method for specific problem.—*CA*

Nine Graphs Speed Calculation of Water Demineralization Costs. F. H. KAHLER & A. C. REENTS. Chem. Eng. **64**:206 ('57). Operating cost data are presented for all of common ion-exchange methods for demineralization of water by employing fixed beds with intermittent regeneration.—*CA*

Split-Treatment Softening of Water. J. R. ROSSUM. Ind. Eng. Chem., **47**:2313 ('55). Softening of portion of water and its recombination with remaining water is

(Continued on page 82 P&R)

(Continued from page 81 P&R)

discussed. Method cannot be used with all waters, but can offer reduced lime consumption and improved water qual. when feasible. To det. what water may be treated, series of eqs. is given. Using raw water data, these can evaluate expected results from softening with lime, lime-soda, or lime zeolite. Eqs. indicate amt. of water bypassed and dosage required to produce desired effluent. Further, by using eqs., cost between split and conventional treatment can be compared and frequent economic advantage of split-treatment detd.—*PHEA*

CORROSION

Corrosion by High-Purity Water. A Symposium. Introduction. J. F. Eckel. Corrosion, 13:70t ('57). Symposium concerns water that has been distributed and (or) deionized so that it will have specific resistance of 500,000 ohm per cm or greater before addn. of any sol. constituents. **Corrosion of Structural Metals in High-Purity Water.** A. H. Roebuck, C. R. Breden & S. Greenberg. Tests showed that materials showing highest corrosion resistance to high-temp. high-purity water included austenitic stainless steels, pptn.-hardening stainless steels, Co alloys, Pt, Ti, Zr, and Hf. Materials of intermediate resistance included Al, Cr, 70–30 Cu-Ni, ferritic and martensitic stainless steels, and Ni and Ni alloys. Lowest resistance was shown by Cu, bronzes, Mg, plain C steels, and Ag. Of factors affecting corrosion, system temp., system gas concn. (especially D.O.), and metal surface are of importance. Techniques which can be used to prep. metal surfaces are discussed and compared. Data are given for machined and vapor-blasted specimens exposed for 500–1,000-hr periods to moving water of various O concns. Surface prepn., especially on stainless steel, must free surface of any contaminant which might prevent or impair formation of film. **Corrosion Engineering Problems in High-Purity Water.** D. J. DePaul. Description is given of some im-

(Continued on page 84 P&R)

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(*Continued from page 82 P&R*)

portant corrosion problems encountered in system exposed to recirculating high-purity water with respect to particular engineering application of materials. Special attention is given to crevice, galvanic, intergranular, and stress corrosion as function of various materials, including 18–8-type stainless steels, Co-base alloys, hard Cr plate, Cu-base alloys, Ni-base alloys, and straight Cr stainless steels. Data are given to show effect of O and clearance on crevice corrosion at 500°F.; also effect of temp. on crevice corrosion in O-bearing water. **The Importance of High-Purity Water Data to Industrial Applications.** W. Z. FRIEND. Uses of high-purity water are listed. Experience has shown that high-purity water is more aggressive than most less-pure waters in corrosion of Fe and steel, particularly if D.O. is present. Review of available information on plant experience indicates that corrosion-resistant metals such as stainless steels, Ni alloys, or Al are generally required to handle high-purity water. At moderate temps. nonmetallic materials such as rubber and vinyl polymers are often used to avoid metallic contamn.—*CA*

Water Corrosion of Structural Materials. A. H. ROEBUCK. Proc. 15th Ann. Water Conf., Engrs. Soc. West. Pa., p. 165 ('54). In an investigation of suitability of structural materials for use in nuclear power plant, expts. were carried out at Argonne National Laboratory, Chicago, Ill., on corrosion by water of wide variety of finished metals and alloys as affected by temp., water purity and alky., D.O. concn., veloc., pressure, and factors relating to physical condition of metal samples. Results are presented and discussed, and metals and alloys tested are classified according to corrosion resistance. In discussion which followed presentation of paper it was pointed out that use of materials of high corrosion resistance is of particular importance in construction of nuclear-powered boiler systems since oxygen is continuously generated by dissociation of water as result of irradiation, and that any corrosion products formed may become radioactive under conditions prevailing in primary system of plant, which, on circulation to exposed parts of system, create health hazard and increase screening requirements. —*WPA*

(*Continued on page 88 P&R*)

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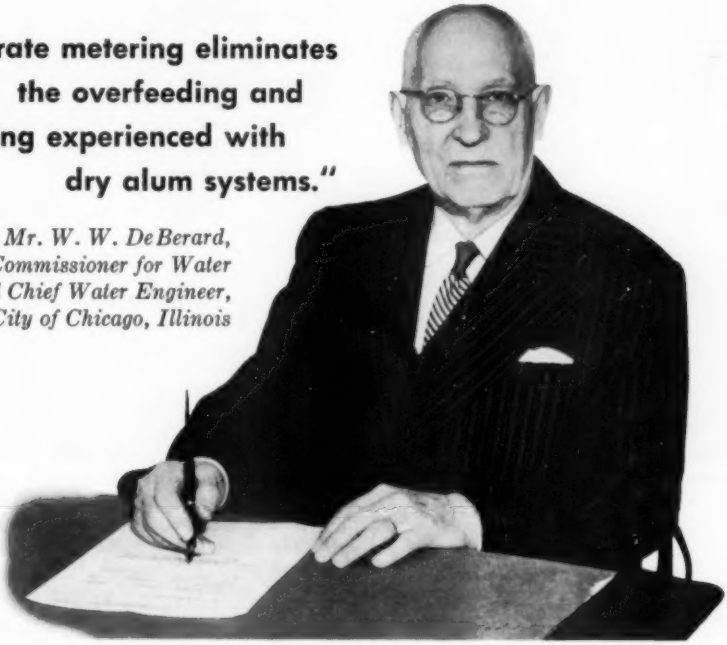
—says Mr. W. W. DeBerard, Deputy Commissioner for Water and Chief Water Engineer, City of Chicago, Illinois



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(Continued from page 84 P&R)

Influence of Water Composition on Corrosion in High-Temperature, High-Purity Water. D. M. WROUGHTON, J. M. SEAMON & P. E. BROWN. ASTM Tech. Publ. No. 179, p. 19 ('56). Except for pH, water compn. within range studied has little influence on corrosion rates of C steel under conditions which may exist in primary coolant of water-cooled and moderated reactors. LiOH appears to be a satisfactory inhibitor. Influence of water compn. on nature or behavior of corrosion products can be more important than its effect on corrosion rates.—*CA*

The Use of Hydrazine to Prevent Oxygen Corrosion. E. C. FISS. Southern Power and Ind. 73:46 ('55). Southern Power Co. experience with use of Na_2SO_3 (I) indicated that it had a number of undesirable characteristics. Above a limiting concn., which was found to be about 10 ppm for 900-lb/sq in. boilers, sulfite decompn. occurred; 5–10 ppm was found to be practical operating range. Furthermore, I is converted into Na_2SO_4 which increases the sol.-salt concn. Boiler water contg. normal concns. of I tended to seep through small openings which would not normally leak boiler water. Tests were begun with hydrazine (II) in 1950, and in 1952 it was used in a 1,500-lb/sq in. boiler that had experienced series of tube failures. It was considered that I would be unsafe to use at these pressures, owing to decompn. After use of II was started, only 2 tube failures occurred; none have occurred in past 2 yrs. Tube sections recently removed from boiler are in satisfactory condition. Sections of tubes were also removed from 2 controlled-circulation boilers which operate at 1,850 lb/sq in. and are being treated with II. These sections were cleaned in inhibited HCl to det. pit depth. No corrosion is occurring at welds. Tube section from another controlled-circulation boiler showed no corrosion evidence. At present time, 17 boilers are being conditioned with II. Amt. of II fed is 3–5 times theoretical amt. required to react with D.O.; this maintains residual II in boiler water and produces NH_3 concn. in feedwater of 0.05–0.15 ppm. Excess II apparently reduces oxides contained in boiler sludges and on boiler surfaces to lower oxides. 2 Methods of feeding hydrazine are shown—both are fabricated almost entirely of Type 304 stainless steel and feed a soln. contg. 0.02 lb II/gal. II, purchased as 85% II hydrate, is dild. to make 0.02-lb. soln. as required. No undue hazards have been found in handling these solns. Water samples are analyzed for II residual by direct iodate titration, endpoint being detd. potentiometrically. Sufficient HCl is added to sample container before sample is collected to make contents 10% concd. HCl by vol. This stabilizes II and makes it insensitive to atmosphere O. An aliquot portion is further acidified with HCl to 3–5*N* and titrated with standard KIO_3 soln. A microburet, readable to 0.001 ml, is used and endpoint detd. by pH indicator with calomel and Pt electrodes. Typical titration curves are given. Residuals of II can be detd. accurately in about 5 min.—*CA*

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Water Meter Corrosion. Progress Report of Task Group T-4F-1. E. W. HENKE, ET AL. Corrosion, 12:77 ('56). Acute water meter corrosion problems seem to be localized, and water meters generally appear to give satisfactory service. Types of corrosion encountered are discussed as are the anals. of specific corrosion products. Special meters with more corrosion-resistant parts are probably justified only for special corrosive waters.—*CA*

(Continued on page 90 P&R)

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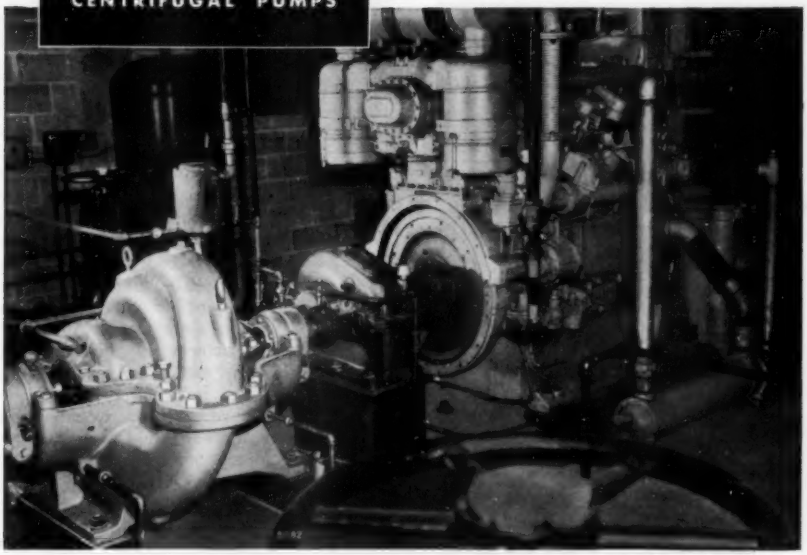
boost pressure at peak loads in Port Washington, New York



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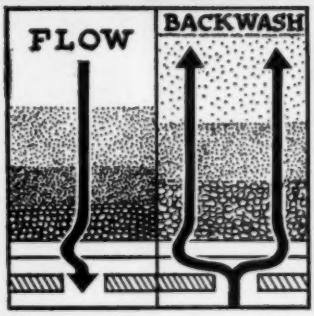

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Practical design assures *constant* flow and *uniform* backwash. With a backwash rate of 36" rise (50% sand expansion) the total loss of head is only 2.5 ft. of water resulting in *initial* savings by purchasing a lower h.p. motor for the pump . . . and continuous savings in pumping costs.

Non-corrosive filter bottoms are scientifically manufactured so that the ports cannot be blocked by gravel . . . closed by encrustation . . . or enlarged. Strong, durable construction withstands *many times* the force of the severest filter run. About *five minutes* and a *screwdriver* completes field assembly and substantially reduces labor and costs.

Write For Literature

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(*Continued from page 88 P&R*)

Studies on the Corrosion of Water Pipes and Their Fittings in Tsubame City. I. HORASAWA, T. IWATO & J. MATSUMOTO. Bull. Inst. Public Health (Jap.), **4**:1 (Sep. '55). In Tsubame City water pipes are heavily corroded, causing leakage, and frequent repairs. This is important not only from standpoint of water works economics but also that of public health. Authors made investigation and expts. in order to study causes of corrosion and to det. counter measures. Results of field survey and lab. expts. summarized as follows: There were 2 types of corrosion. One was aerobic and other anaerobic. Predominant type was anaerobic. Aerobic corrosion was extremely limited. Soil was clay, water table high and drainage poor. pH was 5.8–6.0, giving conditions favorable for development of sulfate-reducing bacteria such as *Sprovibrio*. Activity of sulfate-reducing bacteria was high. Generally the higher the rate of corrosion, higher was bact. activity. Iron sulfide was formed on corroded surface of iron. Countermeasures: Improve drainage and ventilation of soil, prevent injury of water pipes and fittings at time of burial, treat injury surface and use materials and coatings resistant to H_2S.—*PHEA*

Experience Report on Chlorination and Corrosion. G. GÜNTHER. Wasserwirtsch. Tech., **5**:271 ('55). In chlorinating Saale R. water with excess of 0.15–0.20 g. Cl_2/cu m, peculiar corrosion product was observed at rotor ribs of rotary pumps. Material had deposited as soft layer of several mm thickness, striated with rust and black bands. Anal. showed: Fe_2O_3 73.62, phosphate 1.98, SiO_2 1.27, As_2O_3 0.04, sulfide S 0.97, ignition loss 22.6%. High S content in corrosion product gave clue for corrosive substance H_2S. Evidently, oxidation of H_2S by Cl_2 was not complete and residual H_2S in water caused observed corrosion product. H_2S resulted from anaerobic decompn. of river sludge, especially in warm weather.—*CA*

CHEMICAL ANALYSIS

A Micro-Method for the Determination of Organic Carbon in Lake Water. I. FORSBLAD. Mikrochim. Acta, pp. 176–186 ('55). Apparatus is described for continuous evapn. of lake water *in vacuo*. Evapn. is carried out in presence of phosphoric acid to eliminate chloride and carbonate ions.

(*Continued on page 92 P&R*)

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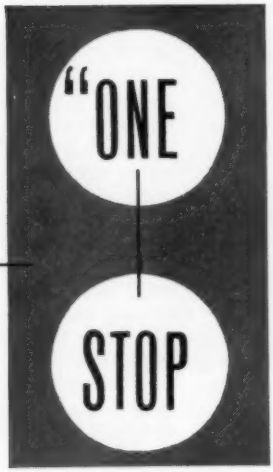

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(*Continued from page 90 P&R*)

Org. residue is then oxidized in evapg. flask in 3 min at 160°C with mixture of potassium chlorate (1.5 g), chromic oxide (15 g), phosphorus pentoxide (30 g), concd. sulfuric acid (130 ml) and 90 per cent phosphoric acid (25 ml). Carbon dioxide produced is absorbed in 0.025 M barium hydroxide solution *in vacuo*, and resulting carbonate is titrated between pH 10 and 3.5, with thymolphthalein and bromophenol blue as indicators. Accuracy is ±1 per cent with samples containing 2 mg of organic matter. Results on lake water are given.—*WPA*

A New Turbidimetric Determination of a Small Amount of Chloride in Water. Y. KITANO & H. TSUBOTA. J. Chem. Soc. Japan, **75**:931 ('54). Turbidimetric anal. of microquantity of chloride ions in natural water is much improved by use of mixed reagent of silver and divalent lead ions. This is because turbid, colloidal solution of silver chloride is markedly stabilized by presence of lead ions. 2 ml of reagent, containing 0.001 mole of silver nitrate and 0.02 mole of lead nitrate per l, are added to 20 ml of sample solution, which contains from 0.01 to 3.0 mg of chloride per l. Soln. is then allowed to stand for 20 min in dark. Turbidity of soln. is compared with that of standard series in Nessler tubes.—*WPA*

Titrimetric Estimation of the Chloride Ion by Use of Eosin as Indicator. J. BOGNAR & J. VERESKOI. Acta. Chim. Acad. Sci. Hung., **5**:105 ('55). Providing that sample is treated with acetic acid (strength more than 0.2 N) and that 50 per cent of alcohol or acetone is added, eosin can be used as an adsorption indicator in the argentimetric estn. of chloride. Optimum chloride ion concn. is 0.01 N. Diln. of chloride ion soln. with other org. liquids had a favorable effect on position of color change of eosin, but only for dioxan is change sufficiently sharp. With dioxan, titration is performed in neutral or acid medium, provided that pH is greater than 2. Presence of other electrolytes does not affect titration.—*WPA*

Rapid Colorimetric Determination of Copper by Means of 2-isatoxime Methyl Ether in the Presence of Other Metals. L. DIVIS & J. SKODA. Chem. Listy (Czech.), **48**:539 ('54). A highly selective method for rapid colorimetric detn. of copper is described. It is based on formation, by reaction between cuprous ion and 2-isatoxime methyl ether, of a colored complex which is sol. in chloroform. Sample is made slightly acidic to give a pH of 5–7, and is treated with sodium potassium tartrate. If mercury is present, potassium iodide is added at this stage, as it masks any interference by mercury. Soln. is then dild., shaken with chloroform, and light absorption is measured with green filter, which has min. absorption at 540 mμ. Details of experimental procedure are given. Copper can be detd, by this method in presence of large excess of silver, zinc, cadmium, lead, manganese, iron, cobalt or nickel.—*WPA*

Determination of Cyanides in Water and Waste Samples. F. J. LUDZACK, W. ALLAN MOORE & C. C. RUCHHOFT. Anal. Chem., **26**:1784 ('54). Effects of various factors on detn. of micro amts. of cyanide (order of 2 CN^- in 25 ml) by 2 colorimetric procedures were investigated. Procedures used were benzidine-pyridine and pyridine-pyrazolone methods. Effects of pH, time, reagent stability, inorg. interfering ions, and amino acids were studied. Isolation of CN^- by various distn. methods, as well as behavior of complex cyanides in distn. procedure, was investigated. Results extended applicability of various anal. procedures investigated.—*CA*

Determination of High Boiling Paraffin Hydrocarbons in Polluted Water. F. J. LUDZACK & C. E. WHITFIELD. Anal. Chem., **28**:157 ('56). Investigations of oil poln. in surface water has frequently been confused by anal. problems. Methods may have failed because of incomplete recovery of oily materials, lack of identification of major components, or inadequate removal of interference. Proposed method includes an improved wet extraction procedure, infrared anal. for quant. and classification purposes, and chromatographic sepn. to isolate mineral oils from animal or vegetable oils, soaps, and miscellaneous extractable components found in pold. water. This procedure makes it possible to determine amount, type, and condition of oily residues in presence of mixed components in pold. water.—*PHEA*

The most efficient main line metering device, the Venturi Tube, has undergone design modifications and standardization to become an even better differential producer. Years of exhaustive tests on head loss, coefficient, recovery angles, and effects of upstream piping . . . conducted in the research laboratory at Builders-Providence . . . have produced 130 standardized constructions designed to give "tailor-made" service to a wider number of applications *more economically*.

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New Bulletin 110-N1 gives complete data on both Builders short form and Hershel Standard Venturi Tubes. Write to . . .
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AMERICAN WATER WORKS ASSOCIATION

2 Park Ave., New York 16, N. Y.

Correspondence

'Hot' Water

To the Editor:

I thought your readers might be interested in the following incident which recently occurred at Macon, Ga. Two of us went out to a small subdivision to check complaints about a musty-moldy taste and odor in the water. We couldn't find the cause, but when we opened a blowoff at the end of the main and put our hands in the water, we both got a shock. The next day a crew was sent to put in a bleeder service near the blowoff, and one of the men received a shock strong enough to knock him down. The crew found that they could make an electric bulb light up brightly by holding it on the hub of one length of main and placing a shovel on the next, with the blade in contact with the bulb threads.

The power company was notified, and the trouble was traced to a faulty "do-it-yourself" installation of a 220-v electric hot-water tank. One result appears to have been the electrical disintegration of the sulfur compound in one of the water main joints, probably because the pipe was not "home" and the packing yarn acted as an insulator. A great amount of electricity must have been consumed, enough to warm up the ground surface in the area appreciably. The odd part was that residents noticed a shock only when taking a bath. The taste and odor may have been due to preservatives in the yarn or pipe coating going into solution.

JOHN A. RAYMOND

New York, N.Y.
Apr. 23, 1957

CONTINUOUS PIPELINE CHEMICAL MIXING

THE HOMOMIX—provides instant, violent, uniform, and complete mixing of one or more chemicals or gases with water—continuously or intermittently, *without the use of a mixing tank!* Designed with one or more stages of direct-connected motor driven diffuser impellers rotating in blending chambers, it forms part of the influent piping. Discharges directly across the flow-through stream. Mixes instantaneously at the point of entry. Lift impeller can be added to provide additional head, if required. *Send for Technical Supplement HM and Bulletin 300.*

IRON AND CARBON DIOXIDE REMOVAL

THE FERROFILTER—removes iron, manganese, carbon dioxide, and other dissolved gases and odors—efficiently and economically, in one simple operation. Utilizes fine media in open aeration. *Write for Bulletin No. 252B.*

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THE FLOCSETTLER—combines in one unit all modern concepts of water and waste treatment, including mixing and slurry blending, slurry recirculation, sludge blanket settling, sludge concentration, and sludge removal. *Send for Technical Supplement FL.*

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PADDLE-PROPELLER-RM TYPE MIXERS—for rapid mixing to obtain continuous blending of chemical with raw water.

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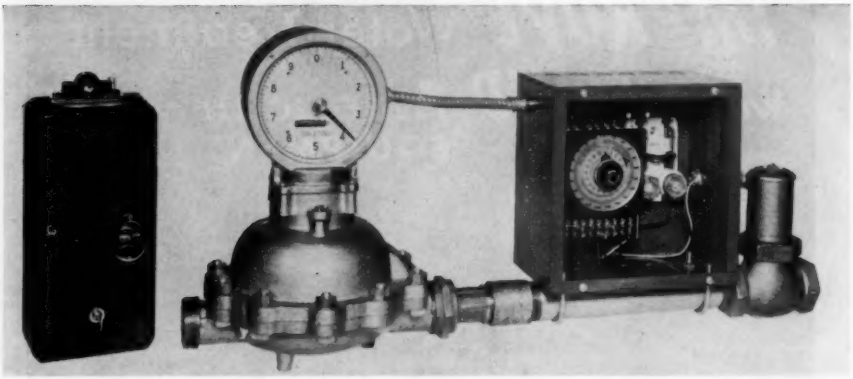
(Continued from page 56 P&R)



A coin-operated, self-service water vending system (photo above) is available for utilities selling to such customers as water delivery services, industrial users, and residents in outlying areas not receiving piped water. A product of Hydro-Control Div., Illes Power Control Co., 22700 Shore Center Drive, Cleveland, Ohio, the "Self-Serve Water Vendor" enables customers to obtain water day or night without the presence of an attendant. The device can be set to meter and deliver from 10 to 4,000 gal when actuated by a coin.

An improved method of accounting for water gains and losses, developed by the US Geological Survey, is expected to play a significant part in the drainage basin studies cited by the President as essential to the nation's progress. Results of a test of the new method in a pilot study of a small drainage basin—Beaverdam Creek, near Salisbury, Md.—are given in a report recently released.

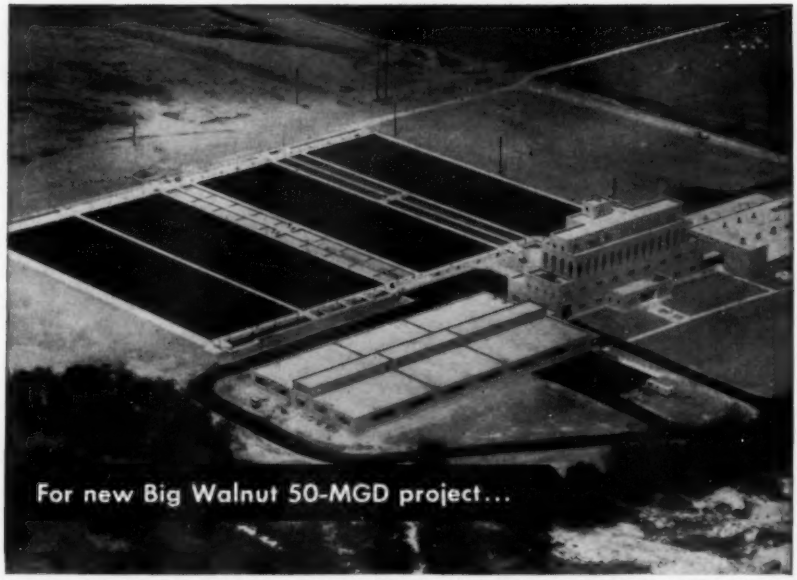
The method involves periodic determination of significant factors such as precipitation, stream flow, storage of water in the stream channels, ground water level, and soil moisture. It also calls for a statistical analysis of factors not so readily measurable, such as the changes in ground water storage and the amount of water evaporated from the soil and transpired by vegetation.

As a part of the statistical analysis, a rating curve was devised to permit the approximation of the amount contributed to a stream by ground water seepage. This development, in turn, led to a better estimate of the total discharge of ground water by runoff to streams, evaporation and transpiration, and addition to storage in the ground. The rating curve is regarded as an important contribution to the science of hydrology.

The pilot study, which was made in cooperation with the Maryland Dept. of Geology, Mines, and Water Resources, was on a small scale, and the precision of the results leaves much to be desired. The study will, however, serve as a foundation for more exacting work, which will add to the nation's basic store of hydrologic information.

The report, "Hydrologic Budget of the Beaverdam Creek Basin, Maryland," by William C. Rasmussen, geologist, and Gordon E. Andreasen,

(Continued on page 98 P&R)



Aerial view of Big Walnut plant. Built for City of Columbus, Ohio—Floyd C. Redick, Director, Department of Public Service; Paul C. Laux, Superintendent of the Division of Water. Uhlman Associates were the consulting engineers for design and construction.

Columbus, Ohio selects Leopold Filter Bottoms, Operating Tables and Carbon Slurry Agitators

Built at an approximate cost of $5,750,000, the Big Walnut project is designed to provide adequate water supply capacity to meet the ever-increasing needs of the City of Columbus. The new, modern facilities (shown above) have a nominal capacity of 50 mgd, a maximum rated capacity of 73 mgd, and are equipped with twelve Leopold five-valve operating tables, six Leopold carbon slurry agitators, and twelve sets of Leopold glazed tile filter bottoms.

Like this new project, more and more water treatment plants are using Leopold equipment—whether for new construction or modernization programs. It will pay you big dividends to do the same! For details on Leopold water purification and filter plant equipment, write today. There's no obligation.

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FILTER OPERATING TABLES · MIXING EQUIPMENT · DRY CHEMICAL FEEDERS
GLAZED TILE FILTER BOTTOMS

(Continued from page 96 P&R)

mathematician, is available in typewritten form for public inspection in offices of the US Geological Survey and is to be published as a water supply paper by USGS.

Rockwell Mfg. Co. has acquired the assets of Republic Flow Meters Co., Chicago, manufacturers of electronic and pneumatic instruments for automatic measurement and control of flow.

Win, place, and show in the Kentucky Derby can apparently be credited to the Louisville Water Co. supply, whereas Mountain Valley water could do no better than fourth. That fourth, by the way, was the preclassic favorite, Bold Ruler, who drinks Arkansas' Mountain Valley spring water wherever he goes, as did Gallant Fox before him, as does his trainer Sunny Jim Fitzimmons, and as do, too, those hard runners, the members of the United States Senate. We haven't compared the constituents of the Louisville and Mountain Valley waters, but we presume the secret of the running is in the mineralization. At any rate, Iron Liege was anything but rusty.

AWS—American Welding Society—has elected Clarence P. Sander president, Gustav O. Hoglund first vice-president, and Charles I. Mac Guffie second vice-president for the 1957–58 fiscal year. Mr. Sander is with US Steel's Consolidated Western Steel Div., Mr. Hoglund with Alcoa, and Mr. Mac Guffie with General Electric Co.

(Continued on page 100 P&R)

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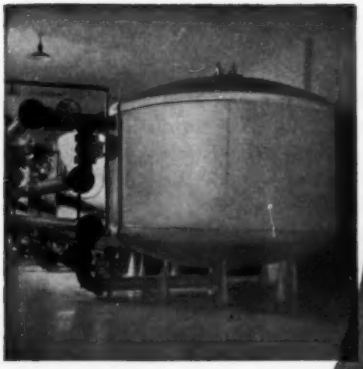
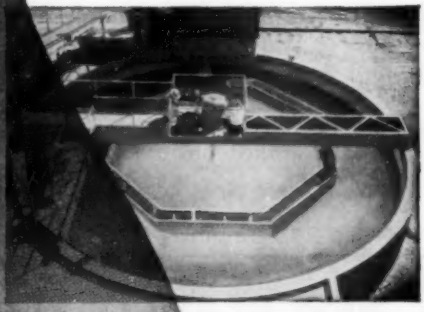


There are many reasons why municipalities and industries have installed General Filter water treating plants:



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Find out why you should specify General Filter . . . Write today for detailed information regarding your water treatment problems.

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(Continued from page 98 P&R)

Martin Lyon, retired superintendent, Clintonville, Wis., Water & Electric Plant, died Apr. 26, 1957, after a long illness. He was 73. During his 38-year tenure as utility superintendent at Clintonville, he did much to keep his department abreast of the city's growth and the technological advances in his field.

An AWWA member since 1941, he was one of the founders of the Wisconsin Section and an active participant in its affairs.

Joseph F. Murray, principal engineer, Div. of Water Supply, Newark, N.J., died Apr. 5, 1957, after a brief illness. Born in Newark, he was graduated from Stevens Institute of Technology. He worked for the Passaic Valley Sewerage Commission before becoming an employee of the city of Newark in 1929. He had been an AWWA member since 1942.

Frederick Ohrt, trustee of the Estate of James Campbell and former manager of the Board of Water Supply, Honolulu, T.H., died Mar. 13, 1957, at the age of 67. Born in Spreckelsville, Maui, T.H., in 1889, he was educated at St. Louis College, University of Oregon, and Cornell. In 1915 he became highway inspector and assistant city engineer at Honolulu, being promoted to city engineer in 1919. He left in 1923 to accept the position of chief engineer with Libby, McNeill & Libby. From 1925 to 1929 he served as chief engineer of the Honolulu

(Continued on page 102 P&R)

NEW BEAUTY THROUGH COLOR

• Painted a delicate green, using green aluminum paint, the 500,000 gallon COLE ovaloid tank shown herewith blends with the foliage, and gives a new attractiveness to a community's water reserve.

The "COLE Ovaloid" is an outstanding type for municipal service in capacities to meet requirements. Provided on structural or tubular towers, they are neat in appearance with minimum maintenance. Stored water is contained in a shallow depth to maintain an almost constant pumping head.

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Thinking about soft water for your community?

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Unloading Bulk Salt from Boxcars —at Lower Cost

Portable Conveyor System. A power-operated belt conveyor of suitable length is placed inside the car door, and salt is then shoveled onto it. A good conveyor for most needs is generally about 16 to 18 feet long and capable of moving salt up a 30° slope. With a conveyor, one 40-ton car can be unloaded in about 12 to 14 man-hours—a 19% saving in time over straight manpower.

Scoop Truck and Conveyor. A scoop truck is simply an enlarged scoop shovel with two small wheels at the bowl of the scoop. Whereas a shovel holds only about 20 lbs. of salt—a scoop truck holds 100 to 150 lbs. With just one of these scoops, a worker can unload 40 tons of salt in 10 hours—and once the job is under way, there's room for two or three more men with scoops.

Automatic Power Shovel. This device consists of a large, power-operated scraper blade mounted on a cable—and is one of today's most popular devices for unloading bulk salt. The scraper is moved toward the end of the car. As soon as this motion stops, a power winch takes hold, to drag the scraper toward the car door. One man can unload a 40-ton car in 2 or 3 hours by this unique method.

Small Gasoline or Electric Tractor Shovel. This is similar to a fork-lift truck, but with a scoop mounted in place of the forks. One man on this type of truck can empty a 40-ton car in 2 or 3 hours—the same as power-shovel unloading. The higher cost of a tractor shovel is often justified when it is made available for other purposes.

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INTERNATIONAL SALT CO., INC.

SCRANTON 2, PA.

(Continued from page 100 P&R)

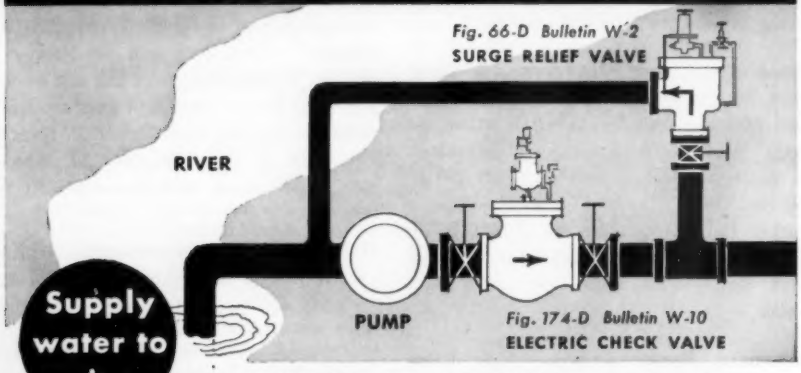
Sewer and Water Commission. In the latter year he was named manager and chief engineer of the Board of Water Supply, a post he held until his retirement in 1952. Water resources development and conservation were his chief concern during the past quarter century, although he saw service on a number of territorial boards and commissions dealing with other matters, especially civil service pension and retirement plans.

In addition to AWWA, Mr. Ohrt belonged to ASCE (honorary member) and the Engineering Assn. of Hawaii (past president).

Cyrus William Rice, chairman of the board of Cyrus William Rice & Co., Pittsburgh, died Apr. 29, 1957, after a long illness. He was 82. Born in Ringtown, Pa., in 1875, he attended Jefferson Medical College, Philadelphia. While employed with Carnegie Steel Co. from 1901 to 1903, he received training and experience in boiler water treatment. In 1904 he was made engineer in charge of steam power and combustion for Atlantic Refining Co., Philadelphia, where he pioneered and developed outstanding methods for water, sewage, and boiler treatment. He founded the consulting firm which bears his name in 1916, serving as president until 1951, when he became board chairman, a position he held until his death. During this portion of his career, he was responsible for many additional refinements of substantial value to water treatment technology.

(Continued on page 104 P&R)

THE G-A SHOCK-TAMER TWINS



The G-A Cushioned Surge Relief Valve protects water lines against excessive surges in the system by automatically opening when the inlet pressure exceeds a predetermined setting.

Check Valve Service without Hammer or Shock

The G-A Double Cushioned Electric Check Valve effectively prevents surge by opening only when pump comes up to speed, closing automatically with pump running and shutting down pump when 95% closed.

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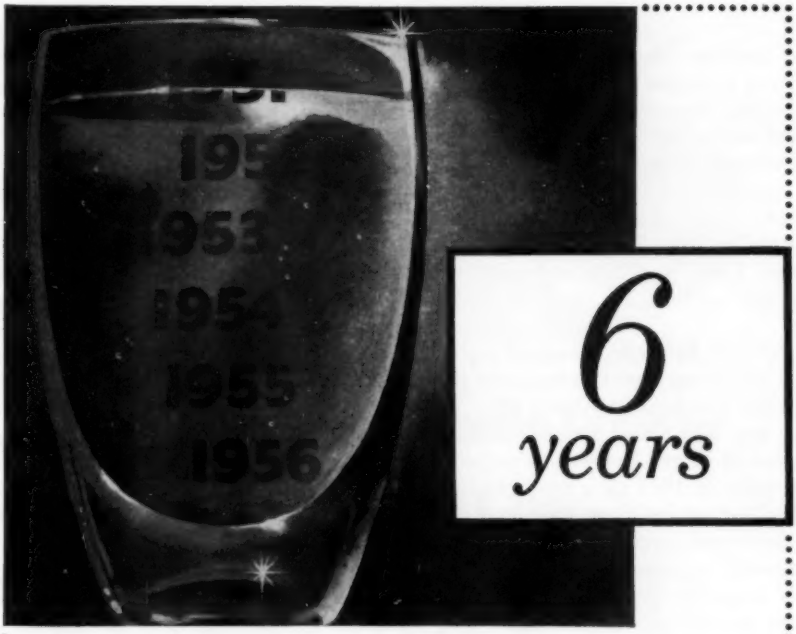

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We emphasize the diatomite filtration system at Cherry Valley, New York, because it has been operating for more than six years, providing the community with clean, safe drinking water at moderate cost.

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For details on this installation, write:

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(Continued from page 102 P&R)

He was one of the principal sponsors of, and a tireless worker for, the Pennsylvania Aqueduct Plan to provide flood control and water supply for the Pittsburgh area.

An AWWA member (first joined in 1924), Mr. Rice also belonged to ASME (fellow), ASCE, and Engineers Club of Philadelphia (charter member).

John C. Schlicht, treasurer and general superintendent of construction and service, Hackensack Water Co., Weehawken, N.J., died Dec. 6, 1956. A native of North Bergen, he joined the company in 1915 as a stenographer in the Construction Dept., but transferred to field work, becoming assistant superintendent of the pipe system in 1926. His responsibility for company operations increased over the years, and in 1938 he was named general superintendent of construction and service. In 1947 he was elected treasurer, in addition to his other duties. He was a Life Member of AWWA (joined in 1926).

Herman W. Snidow, regional engineer, State Dept. of Health, Richmond, Va., died Apr. 22. He was one of the organizers of the Virginia Water & Sewage Works Assn. and was the first secretary-treasurer of the Virginia Section of AWWA. A Life Member of AWWA (joined in 1926), he received the Old Dominion Award in 1951. In 1952, following nomination by the Virginia Section, he was presented with the Fuller Award for "devoted and outstanding service . . . rendered with modesty to the Commonwealth of Virginia in the field of water supply and sanitation; and for his untiring efforts in promoting the Section." In 1956 he was chairman of the Fuller Award Committee.

J. Albert Thomas, vice-president and general manager, Roberts Filter Mfg. Co., Darby, Pa., died suddenly Apr. 11, 1957. He was 54. Mr. Thomas was also vice-president of Roberts Filter Co. of Canada, as well as a director of both companies. He was well known here and abroad for his contributions to the development of major water works projects. Associated with the company for 40 years (and with its Canadian affiliate since incorporation in 1930), he served in various capacities—purchasing agent, sales manager, and engineer. He became general manager in 1943. He represented his firm in AWWA and was active in numerous other water works associations throughout the country.

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Section Meetings

Arizona Section: The 1957 annual meeting of the Arizona Section was held in conjunction with the Arizona Sewage and Water Works Assn. at the Maricopa Inn in Mesa, Apr. 4–6. The total official registration was 234. All technical sessions were held in the Mesa V.F.W. Hall and were exceptionally well attended. [A list of papers presented will be published in the December 1957 JOURNAL.] Some of the highlights of the technical sessions were discussions on sand trouble in water production and distribution facilities, northern Arizona underground water supply, accounting and collecting procedures, and demonstrations of types of joints.

The Apr. 5 business luncheon was attended by 75 members. Participation in the AWWA Safety Award Plan was approved, and the following new officers were elected: Quentin Mees, chairman; A. L. Frick Jr., vice-chairman; and Stanford I. Roth, secretary. Dario Travaini continues as director.

AWWA Vice-President [now President] Merryfield was the principal speaker at the Apr. 5 evening banquet. His subject, "We Sell Water Too Cheap," provided much food for thought. As a token of appreciation, Merryfield was presented with a western-style hat, which occasioned speculation as to whether he would or would not sport it at AWWA meetings. [He did at Atlantic City.—*Ed.*]

The Cocktail Hour and Dinner-Dance on Saturday evening, Apr. 6, had an attendance of 205. Robert M. Cushing was nominated for the Fuller Award. The dinner-dance climaxed a full 3-day program that included fashion shows and luncheon card parties for the ladies.

H. C. BIGGLESTONE
Secretary-Treasurer

Kansas Section: The Kansas Section held its twelfth annual meeting jointly with the Kansas Sewage & Industrial Wastes Assn. at the Broadview Hotel in Wichita, Apr. 10–12, 1957. The total

(*Continued on page 108 P&R*)

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Section Meetings

(Continued from page 106 P&R)

registration was 248, including 31 ladies. The address of welcome was made by the newly elected mayor, E. E. Baird, with response by Section Chairman Van Blarcum. The technical sessions were well attended. [A list of papers presented will appear in the December 1957 JOURNAL.]

An entertaining ladies program, under the direction of Mrs. J. W. Heiney and her committee, included a luncheon and bridge at Innes Tea Room.

The highlight of the meeting was the annual banquet held on Thursday evening. Cliff Titus, personnel management director for Beech Aircraft Corp. spoke on "The American Way." Fred Merryfield, [now] President of AWWA, made the presentation of the Fuller Award to Russell L. Culp, chief, Water Supply Sec., Div. of Sanitation, Kansas Board of Health. Section Chairman Van Blarcum presented the Past Chairman's Certificate to Dorr Pelton of Topeka. Robert Hess, chairman, and Howard Stoltenberg, secretary, of the Certification Examining Board presented 27 Water Works Operator's Certificates.

At the business meeting held on Friday morning after a well attended breakfast, the following Section officers were elected: chairman—Roy F. Bluejacket, Independence; vice-chairman—Henry F. Bruner, Kansas City; trustee—John H. Rateuke, Washington; director—Robert

Arizona Section officers (left to right): Chairman Mees, Vice-Chairman Frick, outgoing Secretary Bigglestone, and his successor, Secretary Roth.

(Continued on page 110 P&R)

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Section Meetings

(Continued from page 108 P&R)

H. Hess, Wichita; and secretary-treasurer—H. W. Badley, Salina.

H. W. BADLEY
Secretary-Treasurer

Montana Section: The 32nd annual meeting of the Montana Section was held jointly with the Montana Sewage & Industrial Wastes Assn. on Apr. 4–6, 1957, at the Rainbow Hotel in Great Falls, with 100 members and guests and 35 ladies attending. George Wright, local Chamber of Commerce chairman, welcomed the group to Great Falls. [A list of the papers presented at the technical sessions will be published in the December 1957 JOURNAL.]

New officers elected by the Section are: chairman—R. G. Cronin, foreman, Water Dept., Montana Power Co., Missoula; vice-chairman—Carl King, city engineer, Chinook; director—D. S. Thomas, district engineer, Board of Fire Underwriters of the Pacific, Great Falls; trustees—C. W. Brinck, director of environmental sanitation, Montana Board of Health, Helena, and E. R. Waldo, general manager, Water Dept., Billings. A. W. Clarkson, assistant director of environmental sanitation, Montana Board of Health, Helena, was reappointed secretary-treasurer.

Activities included a tour of the Great Falls water treatment plant, a visit to Malmstrom Air Force Base, a buffet supper with entertainment, and a dinner-dance, at which President Weir distributed awards to all of the Section's past chairmen, while D. S. Thomas received a Life Membership certificate. The ladies also enjoyed a luncheon at the Country Club, where they were presented with favors and heard a book review by Mrs. Les Hills of Great Falls.

A. W. CLARKSON
Secretary-Treasurer

Montana Section officers: Front row, left to right—Director Thomas, Chairman Cronin, Secretary Clarkson. Rear row—Trustees Brinck and Waldo, Vice-Chairman King.

Top: Torresdale Filter Plant: Morris Knowles, Inc., Design — McCloskey & Co., Construction

Spillway Structure, Greater Chao Phya Project — Royal Irrigation Department

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NEW MEMBERS

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Aldi, Joseph, Contractor, 194 Mariaville Rd., Schenectady, N. Y. (Apr. '57)

Allegany Water Dept., George T. Sendlakowski, Supt. of Water, 7th St., Allegany, N.Y. (Munic. Sv. Sub. Apr. '57) *MD*

Anaconda Co. Reduction Dept., Raymond P. McCarren, Asst. Mech. Supt., Anaconda, Mont. (Corp. M. Apr. '57) *MRP*

Aranda, Frank, Jr., Sr. Draftsman, Metropolitan Water Dist. of Southern Calif., 306 W. 3rd St., Los Angeles, Calif. (Apr. '57) *D*

Baer, Parry G.; *see* Croswell (Mich.) Water Dept.

Bango, Rafael Garcia, Cons. Engr., 22 #503 Miramar, Havana, Cuba (Apr. '57)

Bay Minette Water Works & Gas Board, Ted Fraser, Utilities Supt., Bay Minette, Ala. (Corp. M. Apr. '57) MD

Bahee, John W., Distr. System Engr., Wichita Water Co., Wichita, Kan. (Apr. '57) *MD*

Bellevue Munic. Light & Water, Claude W. White, Supt., 900 N. Water St., Bellevue, Iowa (Munic. Sv. Sub. Apr. '57) *MD*

Bengel, M. A.; *see* Duarte (Calif.) Water Co.

Berasategui, Juan, Civ. Engr., Calle K, No. 303, Apdo. 22, Vedado, Habana, Cuba (Apr. '57) *R*

Bley, Frederick, Water Works, Fairfield, Ohio (Apr. '57) *MP*

Bosa, Louis, Sr., Civ. Engr., East Bay Munic. Utility Dist., Oakland, Calif. (Apr. '57) *MP*

Bowen, M. D., Contractor, M. D. Bowen Co., Wautoma, Wis. (Apr. '57) *RPD*

Brodermann, Jorge, Civ. Engr., Calle 23, No. 1008, Vedado, Habana, Cuba (Apr. '57)

Burr, Don T., Distr. System Engr., Wichita Water Co., Box 1442, Wichita, Kan. (Apr. '57) *D*

Butrico, Frank A., Chief, Office of Eng. Resources, U.S. Public Health Service, DHEW, 4110 South Bldg., 4th & C, Washington, D. C. (Apr. '57) *R*

Caufield, James D., Cons. Engr., Caufield & Caufield, 402 Pearson Bldg., Portland 4, Ore. (Apr. '57) *D*

Chotard, Marc P., Civ. Eng. Assoc., Dept. of Water & Power, Box 3669 Terminal Annex, Los Angeles, Calif. (Apr. '57) *MR*

Cochran, Robert L., Jr., Vice-Pres., R. L. Cochrane Co., 2241 Y St., Lincoln, Nebr. (Apr. '57) *RP*

Conyers, Gabe, Supt., Water Works, Huntington, Tenn. (Apr. '57) *PD*

Coyne, James Joseph, Sr. Sanitarian, Albany County Health Dept., 409 Madison Ave., Albany, N. Y. (Apr. '57) *P*

Cronkright, Arthur B., Mgr., Port Chester Water Works, Inc., 25 Willett Ave., Port Chester, N.Y. (Jan. '57)

Crosswell Water Dept., Parry G. Baer, Supt. of Utilities, 100 N. Howard Ave., Crosswell, Mich. (Munic. Sv. Sub. Apr. '57) *M*

Daniels, J. W.; *see* Lawrenceburg (Tenn.) Water Dept.

Driscoll, Eugene D., Student, Mass. Institute of Technology, Cambridge 39, Mass. (Jr. M. Apr. '57) *P*

Duarte Water Co., M. A. Bengel, Vice-Pres., 1101 S. Oak Ave., Duarte, Calif. (Corp. M. Apr. '57) *MRP*

Dzierzanowski, LeRoy V., San. Engr., Cook County Dept. of Public Health, 437 S. Walcott, Chicago, Ill. (Apr. '57) *MRP*

Earl, Homer, Supt., Water Dept., Otsego, Mich. (Apr. '57) *MR*

Edwards, A. F., Assoc. Engr., H. H. Angus & Assocs., Inc., 51 Whittaker Cres., Willowdale, Ont. (Jan. '57)

Edwards, Paul E., Mgr., Munic. Water Works, Box 206, Camden, Ark. (Apr. '57) *M*

Ehrich, Glen G., Project Engr., Stanley Eng. Co., Muscatine, Iowa (Apr. '57) *MRPD*

Farmer, Hugh C., Engr., Water Div., Dept. of Public Utilities, 1660 S. 53rd St., Tacoma 8, Wash. (Apr. '57)

Farnell, William A., Plant Supt., Anthes-Imperial Co., Ltd., 1350 Sasketchewan Ave., N., Winnipeg, Man. (Jan. '57) *MD*

Fehr, Charles M., Tech. Service Repr., Pennsylvania Salt Mfg. Co., 3 Penn Center Plaza, Philadelphia, Pa. (Apr. '57) *P*

Fishback, William Primrose, Civ. Engr., Ken Fishbeck Civ. Eng. Cons., 2119 W. St. Joseph St., Lansing, Mich. (Apr. '57 *RPD*

Fitzgerald, W. P., Mgr., John Wiley Jones Co., Inc., 1904 Border Ave., Torrance, Calif. (Apr. '57) *P*

Fondren, J. H., Supt., Waterworks, Eudora, Ark. (Apr. '57) *MPD*

Ford, Hugh Stephen, Supt. of Water, Germantown, Tenn. (Apr. '57)

Franci, Walter J., Design Engr., M. M. Dillon & Co., Ltd., 141 Maple St., London, Ont. (Jan. '57)

Franklin, William W., Div. Mgr., Southern Calif. Water Co., 11911 S. Vermont, Los Angeles, Calif. (Apr. '57) *MD*

Fraser, Ted; *see* Bay Minette (Ala.) Water Works & Gas Board

Furrey, Elbert Meryl, Supt., Flowing Wells Irrigation Dist., 900 W. Prince Rd., Tucson, Ariz. (Apr. '57) *MD*

Geraghty, James J., Ground Water Geologist, Leggette, Brashears & Graham, 551 5th Ave., New York, N.Y. (Apr. '57) *R*

Gerin, Jacques, Engr., Eternit, S. A., Belgium, c/o Indussa Corp., 511 5th Ave., New York, N.Y. (Apr. '57) *D*

Guam Public Utility Agency, Box 719, Agand, Guam (Corp. M. Apr. '57) *MRPD*

Hancock, Philip, Supt., Water Purification Plant, Water, Light & Power, Springfield, Ill. (Apr. '57) *MP*

Harza Eng. Co., H. W. Nieman, San. Engr., 400 W. Madison St., Chicago 6, Ill. (Corp. M. Apr. '57) *R*

Huckabee, R. Joseph, City Engr., Burley, Idaho (Apr. '57) *D*

Jackson, Edward E., Sr. Hydraulic Engr., Design & Estimate Sec., Feather River Project, State Dept. of Water Resources, 225 S. Marguerita Ave., Alhambra, Calif. (Apr. '57) *RD*

Johnson, Elmer A., Cons. Engr., Box 501, Lincoln, Calif. (Apr. '57)

Jones, Everett L., Supt. Water Dept., 425 N.E. Hill St., Sheridan, Ore. (Apr. '57)

Kadota, Katsuyoshi, Chief, Utilities Branch, U.S. Army Eng. Group, APO 331, San Francisco, Calif. (Apr. '57) *MRPD*

Kalisz, Edwin M., Civ. Engr. II, Water Const. Dept., City Hall, Milwaukee, Wis. (Apr. '57) *MD*

Kelley, William Driscoll, Supt. of Water & Sewage, Box 125, McKenzie, Tenn. (Apr. '57) *MRPD*

Koenitzer, George H., Sales Engr., Dorr-Oliver, Inc., 14700 Detroit Ave., Cleveland 7, Ohio (Apr. '57) *P*

Krantz, Conrad Andre, Mgr., Public Utilities, Box 26, Sitka, Alaska (Apr. '57) *MRPD*

Krum, Harry J., Jr., San. Engr., U. S. Air Force, Headquarters Continental Air Command, Mitchell Air Force Base, New York (Apr. '57) *MRD*

Kuster, R. E., Union Gas Co. of Canada, Ltd., Chatham, Ont. (Jan. '57)

Lanthier, John N., Sales Mgr., Lee Co., 315 Boulevard, Pompton Plains, N.J. (Jul. '50)

Lauritsen, Irene M., Civ. Eng. Draftsman, Dept. of Water & Power, Los Angeles, Calif. (Apr. '57) *D*

Lawrenceburg Water Dept., J. W. Daniels, Supt., City Hall, Lawrenceburg, Tenn. (Corp. M. Apr. '57)

(*Continued on page 116 P&R*)

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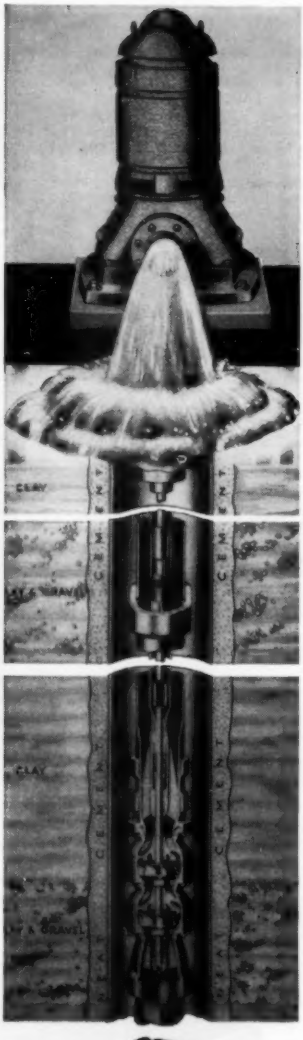

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(*Continued from page 114 P&R*)

Lewis, Roger W., Sanitarian, Muskegon County Health Dept., 36 W. Muskegon Ave., Muskegon, Mich. (Apr. '57) *RP*

Liebzelt, Earl Harry, Maintenance Man, Water Plant, 36570 Jefferson R#8, Mt. Clemens, Mich. (Apr. '57) *P*

Lindebarier, Myron J., Plant Supt., Munic. Water Works, 1016 S. College, Stuttgart, Ark. (Apr. '57)

Lubbock, Wendell T., Chief Oper., Plant Sec., Dept. of Utilities, 13222 Berwick, Houston 15, Tex. (Apr. '57)

MacLennan, Harry P., Gen. Mgr., Taylor Township Water & Sewer Comm., 24409 Eureka Rd., Wyandotte, Mich. (Apr. '57)

Madison, Carl Kellen, Vice-Pres., Rockwell Mfg. Co., 400 N. Lexington Ave., Pittsburgh, Pa. (Apr. '57) *MD*

Main, Kenneth L., Supt., Waterworks, Marshalltown, Iowa (Apr. '57) *MD*

Martinez, Edmund, Civ. Engr. Draftsman, Dept. of Water & Power, Los Angeles, Calif. (Apr. '57) *D*

Mason, Frank C., Bayou Lafourche Fresh Water Dist., Box 369, Thibodaux, La. (Apr. '57)

McCabe, Harold H., Foreman, Meter Div., Water Dept., W. 8th St. Annex, Bayonne, N.J. (Apr. '57) *MRPD*

McCarren, Raymond P.; *see* Anaconda (Mont.) Co. Reduction Dept.

McClure, Alex, Sales Engr., Western Canada, Koppers Products, Ltd., 202 Barry Bldg., Edmonton, Alta. (Apr. '57)

Moody, Tam David, Orange City Water Co., Orange City, Fla. (Apr. '57) *MPD*

Nagel, William Harvey, Commanding Officer, Southern Area Preventive Sec., US Army Hospital, Bad Cannstatt, APO 154, New York, N.Y. (Apr. '57) *P*

Neilan, John B.; *see* Neilan Engrs. (Pa.)

Neilan Engrs., John B. Neilan, Partner, 150 W. Union St., Somerset, Pa. (Corp. M. Apr. '57) *MRPD*

Newton, John O., Office Mgr., Wichita Water Co., 301 N. Main St., Wichita, Kan. (Apr. '57) *M*

Nieman, H. W.; *see* Harza Eng. Co. (Ill.)

O'Connor, Roderich, Salesman, James B. Clow & Sons, Inc., 201 N. Talman Ave., Chicago, Ill. (Apr. '57) *PD*

Ohly, Stuart Z., Salesman, Johns-Manville Sales Corp., 1220 Madison Ave., Toledo, Ohio (Apr. '57)

Olynyk, Peter J., Pres., Olynyk Const. Ltd., 650 Albert St., Regina, Sask. (Jan. '57)

Otsego Service Dept., Water Div., James R. Schubert, City Mgr., 109 E. Orleans St., Otsego, Mich. (Corp. M. Apr. '57) *MD*

Pakalnins, Andrejs, Assoc. Prof. Munic. Eng., Faculty of Eng., McGill Univ., Montreal, Que. (Jan. '57)

Palmer, John V., Wallace & Tiernan, Inc., 3983 Zarthan Ave., Minneapolis, Minn. (Apr. '57)

Poole, Robert Earle, Design Draftsman, H. H. Angus & Assocs., 1441 Eglington St., W., Toronto, Ont. (Jan. '57)

Poston, J. C., Supt. of Waterworks, 1149 Nenleaze Ave., Moose Jaw, Sask. (Apr. '57)

Richardson, Abe, Supt. of Water Distr., Box 4226, Beaumont, Tex. (Apr. '57)

Richter, John Charles, Civ. Engr., Inspection Div., Water Works, Milwaukee, Wis. (Apr. '57) *MD*

Ridgecrest County Water Dist., Ingold H. Schermerhorn, Pres. of Bd. of Directors, Box 426, Ridgecrest, Calif. (Corp. M. Apr. '57) *MD*

(*Continued on page 118 P&R*)

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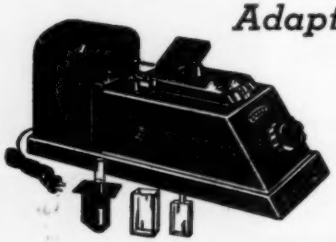

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(*Continued from page 116 P&R*)

Romine, Glenn E., Civ. Engr. Asst., Dept. of Water & Power, 316 W. 2nd St., Los Angeles, Calif. (Apr. '57) *D*

Rowland, Walter F., Instructor in Civ. Engr., Univ. of Illinois, Urbana, Ill. (Apr. '57) *R*

Salotto, B. Vincente, Analytical Chemist, U.S. Geological Survey, Water Resources Div., 510 Rudge Guenzel Bldg., Lincoln, Nebr. (Apr. '57) *RP*

Sandor, Charles, Supt. of Operations, Water Dept., Hammond, Ind. (Apr. '57) *MP*

Savage, E. Stuart, Sales Engr., Dorr-Oliver, Inc., 14700 Detroit Ave., Cleveland, Ohio (Apr. '57) *P*

Schermerhorn, Ingold H.; *see* Ridgecrest County (Calif.) Water Dist.

Schmucker, Raymond W., Mgr., Dept. of Collections, B-25, City Hall Annex, Philadelphia 7, Pa. (Apr. '57) *M*

Schubert, James R.; *see* Otsego (Mich.) Service Dept.

Sendlakowski, George T.; *see* Allegany (N.Y.) Water Dept.

Simmons, Edward T., Ground Water Geologist, Leggette, Brashears & Graham, 551 5th Ave., New York, N.Y. (Apr. '57) *R*

Skinner, John H., Chief Chemist, Kerr-McGee Oil Industries, Inc., Box 125, Wynnewood, Okla. (Apr. '57) *RP*

Smith, Robert L., Exec. Secy., State Water Resources Bd., 644 New England Bldg., Topeka, Kan. (Apr. '57) *R*

Spessard, Clayton I., Sr. Research Engr., Consolidated Western Steel Co., 5700 S. Eastern Ave., Los Angeles, Calif. (Apr. '57)

Stapp, James A., Jr., Sr. Designing Engr., Washington Suburban San. Comm., Hyattsville, Md. (Apr. '57) *D*

Starr, John D., Const. Foreman, Water Dist. Div., Rm. 404, City Hall, Chicago, Ill. (Apr. '57) *M*

Stein, John, Asst. Supt., Waterworks Dept., Bd. of Public Affairs, Ashley, Ohio (Apr. '57) *MP*

Sterrett, W. M., Director of Public Utilities, County of Henrico, Box 3-V, Richmond, Va. (Apr. '57) *M*

Stewart, John N., Salesman, Pennsylvania Salt Mfg. Co., 152 Market St., Paterson, N. J. (Apr. '57) *MRPD*

Thompson, Billy J., Supt. of Water Works, Lonoke, Ark. (Apr. '57) *M*

Vernon, Robert O., Asst. Director, Florida Geological Survey, Box 631, Tallahassee, Fla. (Apr. '57) *R*

Volz, George Stephen, Partner, George Stephen Volz, Ripley, Tenn. (Apr. '57) *PD*

Ward, Sam B., City Engr., Billings, Mont. (Apr. '57)

Weatherford, Richard L., Asst. Chemist, State Water Survey, Champaign, Ill. (Apr. '57) *P*

Wendt, Walter O., Elec. Engr. II, Water Const. Div., Rm. 401, 200 E. Wells St., Milwaukee, Wis. (Apr. '57) *M*

Weston, Arthur D., Edgartown, Martha's Vineyard, Mass. (Apr. '57)

White, Claude W., Supt., Munic. Light & Water, 900 N. Water St., Bellevue, Iowa (Apr. '57) *MD*

White, Claude W.; *see* Bellevue (Iowa) Munic. Light & Water

Wilhelm, Gustave C., Supt. of Water, City Hall, Dyersville, Iowa (Apr. '57) *MRD*

Williams, Harrison Lonnie, Supt., Water Dept., City Hall, Dumas, Ark. (Apr. '57) *MD*

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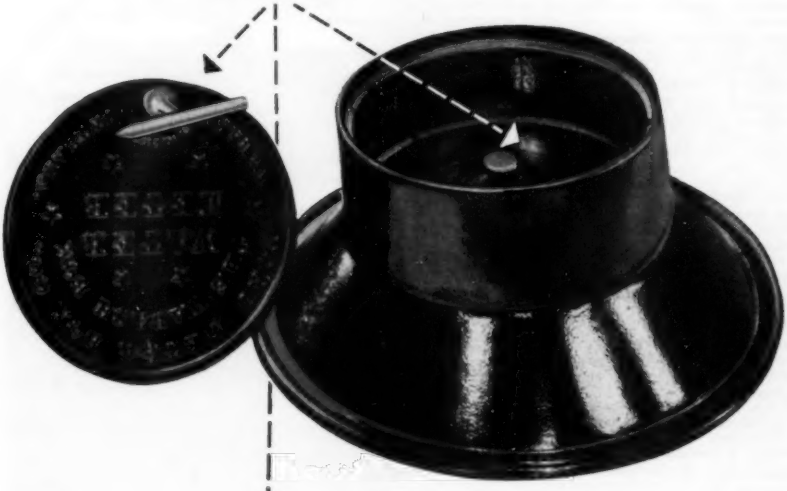

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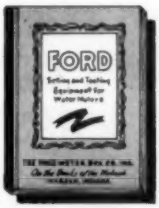

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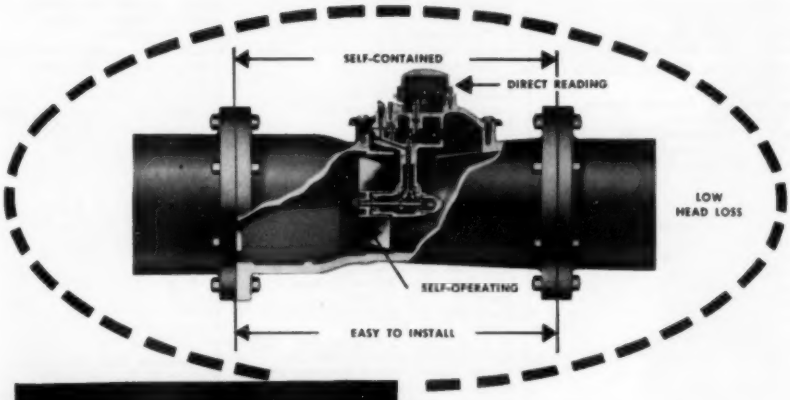

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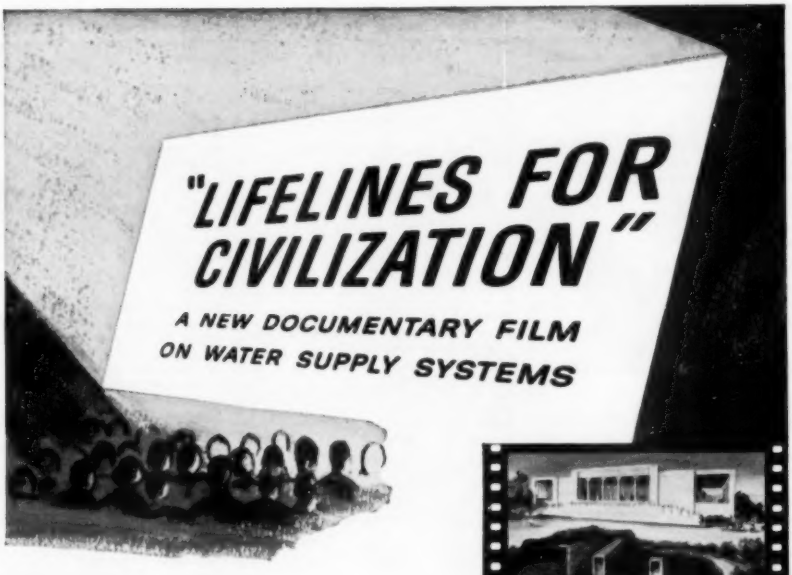

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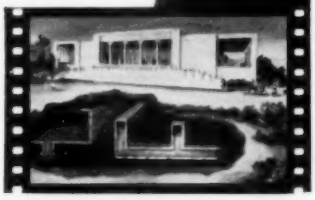

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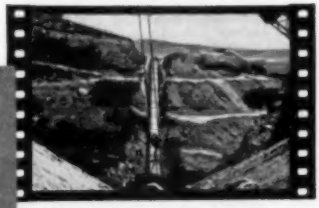

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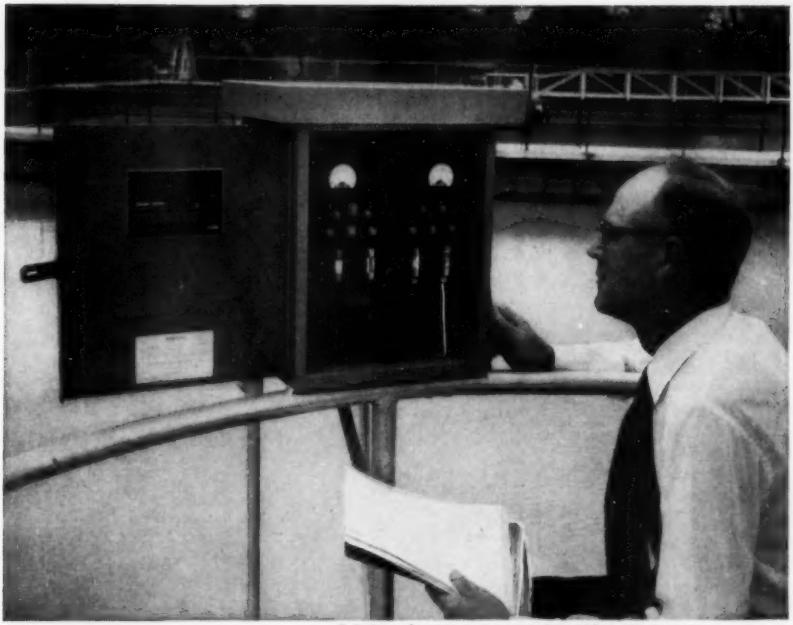


E. R. P. engineer inspects control panel for cathodic system protecting clarifiers at Louisville Water Co., Louisville, Ky.

E. R. P. CATHODIC PROTECTION

stops corrosion at lowest overall cost

Electro Rust-Proofing Cathodic Protection is used by the Louisville Water Company to prevent corrosion of metal underwater equipment in the raw water clarifiers.

Cathodic protection is the one method able to reduce corrosion of underwater metal virtually to zero. Electro Rust-Proofing Cathodic Systems are designed to provide the sole protection of submerged structures or to supplement a good protective coating. When used in conjunction with coatings, cathodic protection eliminates corrosion due to holidays or inherent breaks in coatings such as can occur at many inaccessible structural joints.

Electro Rust-Proofing designs every cathodic system individually so that maximum protection is given for the lowest operating cost. For information about E.R.P. Cathodic Protection, write for Bulletin #E-39.

E.R.P.

ELECTRO RUST-PROOFING CORP.

A SUBSIDIARY OF WALLACE & TIERNAN INC

30 MAIN STREET, BELLEVILLE 9, NEW JERSEY

Strainers, Suction:
James B. Clow & Sons
M. Greenberg's Sons
Johnson, Edward E., Inc.
R. D. Wood Co.

Surface Wash Equipment:
Cochrane Corp.
Permutit Co.

Swimming Pool Sterilization:
Builders-Providence, Inc. (Div., B-I-F Industries)
Fischer & Porter Co.
Omega Machine Co. (Div., B-I-F Industries)
Proportioneers, Inc. (Div., B-I-F Industries)
Wallace & Tiernan Inc.

Tanks, Steel:
Alco Products, Inc.
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
R. D. Cole Mfg. Co.
Graver Tank & Mfg. Co.
Hammond Iron Works
Pittsburgh-Des Moines Steel Co.

Tapping-Drilling Machines:
Hays Mfg. Co.
Mueller Co.
A. P. Smith Mfg. Co.

Tapping Machines, Corp.:
Hays Mfg. Co.
Mueller Co.

Taste and Odor Removal:
Builders-Providence, Inc. (Div., B-I-F Industries)
Cochrane Corp.
General Filter Co.
Graver Water Conditioning Co.
Industrial Chemical Sales Div.
Infilco Inc.
Permutit Co.
Proportioneers, Inc. (Div., B-I-F Industries)
Wallace & Tiernan Inc.

Tenoning Tools:
Spring Load Mfg. Corp.

Turbidimetric Apparatus (For Turbidity and Sulfate Determinations):
Wallace & Tiernan Inc.

Turbines, Steam:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.

Turbines, Water:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.

Valve Boxes:
James B. Clow & Sons
Ford Meter Box Co.
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
Trinity Valley Iron & Steel Co.
R. D. Wood Co.

Valve-Inserting Machines:
Mueller Co.
A. P. Smith Mfg. Co.

Valves, Altitude:
Golden-Anderson Valve Specialty Co.
W. S. Rockwell Co.
Ross Valve Mfg. Co., Inc.
S. Morgan Smith Co.

Valves, Butterfly, Check, Flap, Foot, Hose, Mud and Plug:
Builders-Providence, Inc. (Div., B-I-F Industries)
Chapman Valve Mfg. Co.
James B. Clow & Sons
DeZurik Corp.
M. Greenberg's Sons
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
S. Morgan Smith Co.
R. D. Wood Co.

Valves, Detector Check:
Hersey Mfg. Co.

Valves, Electrically Operated:
Builders-Providence, Inc. (Div., B-I-F Industries)
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
DeZurik Corp.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
S. Morgan Smith Co.

Valves, Float:
James B. Clow & Sons
Golden-Anderson Valve Specialty Co.
Henry Pratt Co.
W. S. Rockwell Co.
Ross Valve Mfg. Co., Inc.

Valves, Gate:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
DeZurik Corp.
Dresser Mfg. Div.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Hydraulically Operated:
Builders-Providence, Inc. (Div., B-I-F Industries)
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
DeZurik Corp.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
F. B. Leopold Co.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
S. Morgan Smith Co.
R. D. Wood Co.

Valves, Large Diameter:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Muller Co.
Henry Pratt Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
S. Morgan Smith Co.
R. D. Wood Co.

Valves, Regulating:
DeZurik Corp.
Foster Eng. Co.
Golden-Anderson Valve Specialty Co.
Minneapolis-Honeywell Regulator Co.
Mueller Co.
Henry Pratt Co.
W. S. Rockwell Co.
Ross Valve Mfg. Co.
S. Morgan Smith Co.

Valves, Swing Check:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
M. Greenberg's Sons
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Venturi Tubes:
Builders-Providence, Inc. (Div., B-I-F Industries)
Infilco Inc.
Simplex Valve & Meter Co.

Waterproofing:
Barrett Div.
Inertol Co., Inc.
Koppers Co., Inc.

Water Softening Plants; see Softeners

Water Supply Contractors:
Layne & Bowler, Inc.

Water Testing Apparatus:
Wallace & Tiernan Inc.

Water Treatment Plants:
American Well Works
Chain Belt Co.
Chicago Bridge & Iron Co.
Cochrane Corp.
Dorr-Oliver Inc.
Etablissements Degremont
Fischer & Porter Co.
General Filter Co.
Graver Water Conditioning Co.
Hammond Iron Works
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Pittsburgh-Des Moines Steel Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Wallace & Tiernan Inc.

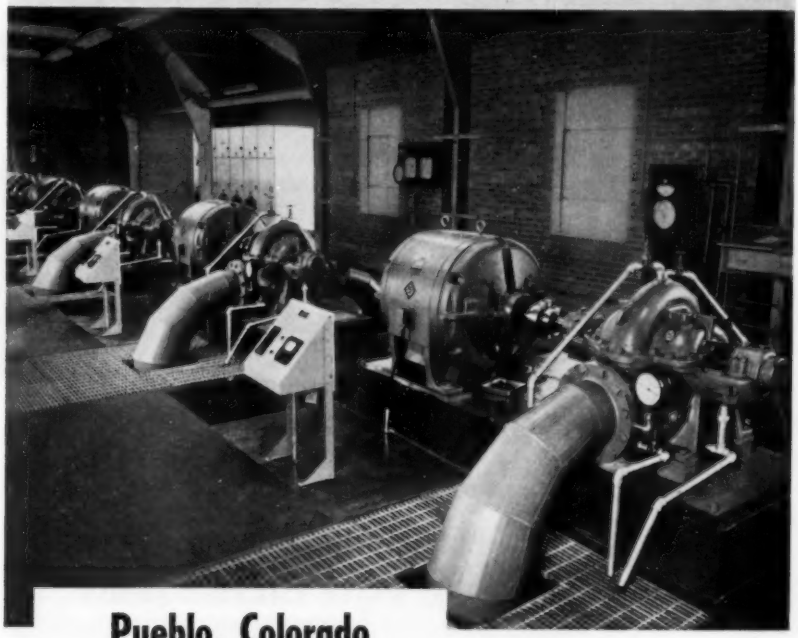
Well Drilling Contractors:
Layne & Bowler, Inc.

Wrenches, Ratchet:
Dresser Mfg. Div.

Zeolite: see Ion Exchange Materials

A complete Buyers' Guide to all water works products and services offered by AWWA Associate Members appears in the 1955 AWWA Directory.

Allis-Chalmers **PUMPS** solve a water works problem



Pueblo, Colorado again purchases Allis-Chalmers Equipment for increased water capacity

Public Water Works No. 2, Pueblo, Colorado . . . two 12 by 10 SHS pumps, 3500 gpm, 290-ft head, driven by 350-hp, 1770-rpm Allis-Chalmers motors — and three 12 by 10 SH pumps, 6000 gpm, 290-ft head, with 600-hp, 1770-rpm Allis-Chalmers motors.

This progressive industrial city of over 100,000 expects to double its population in less than 30 years. This growth pattern called for immediate increased capacity and plans for future expansion. Because Allis-Chalmers pumps have been giving long, dependable service with minimum maintenance, Pueblo specified Allis-Chalmers again.

Why you get MORE pump value when you specify Allis-Chalmers

You draw on Allis-Chalmers wide experience in supplying pumps for public works . . . for expert engineering and application help. You get pumps made of best-quality materials, of heavy duty construction, of high-efficiency design. Allis-Chalmers is the only company that offers you "one source" responsibility, with a complete unit — pump, motor and control — all built to work together — all built by Allis-Chalmers.

For MORE information, call your local A-C office, or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin.

A-C ALLIS-CHALMERS

A-5393

ALLIS-CHALMERS

Did You Know This About Water Meters?

METERS APPORTION WATER CHARGES FAIRLY

Meters accurately record the amount of water your customers use. They pay only for this amount. They pay you at a fair rate established by your utility to cover *the proportionate share* of the cost for gathering the water and delivering it sparkling pure to homes and industry.

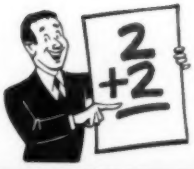
METERS DISCOURAGE WATER WASTE

Wasted water is an expensive luxury. Unnecessary water usage can endanger the welfare of an entire community. With a meter standing guard over each service, water waste is discouraged. Everyone benefits by having an assured supply of water for every normal need.

METERS ARE ACCURATE, LONG LIVED

You can rely on the accuracy of meters, for water meters are precision instruments made and carefully tested to measure exactly the amount of water used. Periodic maintenance and repair will keep meters performing like new for many years.

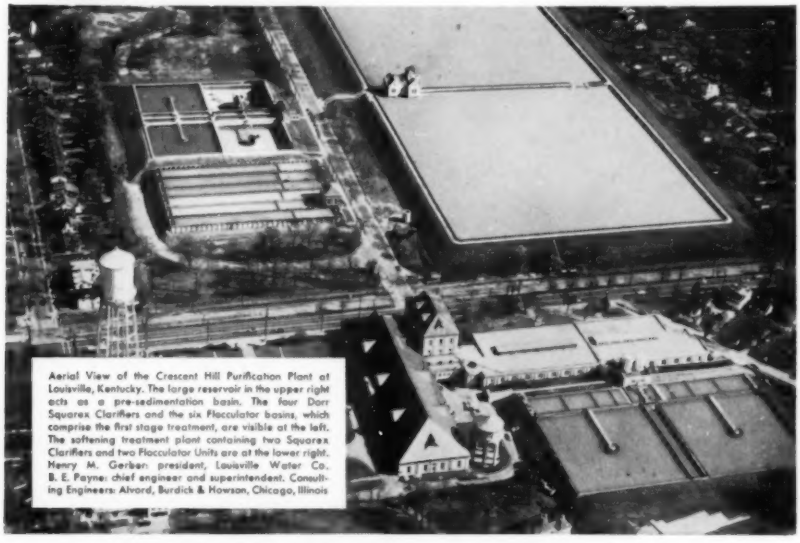
ROCKWELL MANUFACTURING COMPANY
Pittsburgh 8, Pa.



The solution to this problem is always the same . . . but

Water Treatment Problems are different

No two water treatment problems are exactly alike. The right solution to each can only be arrived at after a careful study of the local conditions. Variables such as raw water composition, rate of flow and results required automatically rule out the cure-all approach. The installation shown below is a good example of how equipment should be selected to fit the job . . . and not vice versa.



Aerial View of the Crescent Hill Purification Plant at Louisville, Kentucky. The large reservoir in the upper right acts as a pre-sedimentation basin. The four Dorr Squarex Clarifiers and the six Flocculator basins, which comprise the first stage treatment, are visible at the left. The softening treatment plant containing two Squarex Clarifiers and two Flocculator Units are at the lower right. Henry M. Gerber: president, Louisville Water Co. B. E. Payne: chief engineer and superintendent. Consulting Engineers: Alvord, Burdick & Howson, Chicago, Illinois

Louisville, Kentucky

Adds More Dorr Squarex Clarifiers for Increased Capacity

One hundred years ago the Louisville Water Company began construction of their water plant facilities with the erection of their first pumping station. In the early thirties six Dorrco Flocculator Units were installed for coagulation with a design capacity of 60 MGD. In 1945 two type SZ Dorr Squarex Clarifiers, each 200′ square, and two Flocculator Units for basins 176′ long, were installed inaugurating Louisville's softening treatment plant.

By 1954 rapid population increases necessitated a proportionate increase in water supply requirements, and four Dorr Squarex Clarifiers, each 150′ square, were installed in the first stage increasing the design capacity to 160 MGD.

Two additional Dorr Squarex Clarifiers, each 200′ square, and two type P Flocculator Units, for basins 179′ long and 50′ wide, have been ordered, which will provide softening for 160 MGD.

If you would like more information on the complete line of Dorr-Oliver Water Treatment Equipment, write Dorr-Oliver Incorporated, Stamford, Conn., for a copy of Bulletin No. 9141.

Every day over 8½ billion gallons of water are treated by Dorr-Oliver equipment

Squarex and Flocculator trademarks reg. U. S. Pat. Off.

DORR-OLIVER
INCORPORATED
WORLD-WIDE RESEARCH • ENGINEERING • EQUIPMENT
STAMFORD • CONNECTICUT • U. S. A.

LEADITE

Trade Mark Registered U. S. Pat. Office

Jointed for . . . Permanence with LEADITE

Generally speaking, most Water Mains are buried beneath the Earth's surface, to be forgotten,—they are to a large extent, laid for permanency. Not only must the pipe itself be dependable and long lived,—but the joints also must be tight, flexible, and long lived,—else leaky joints are apt to cause the great expense of digging up well-paved streets, beautiful parks and estates, etc.

Thus the "jointing material" used for bell and spigot Water Mains MUST BE GOOD,—MUST BE DEPENDABLE,—and that is just why so many Engineers, Water Works Men and Contractors aim to PLAY ABSOLUTELY SAFE, by specifying and using LEADITE.

Time has proven that LEADITE not only makes a tight durable joint,—but that it improves with age.

The pioneer self-caulking material for c. i. pipe.
Tested and used for over 40 years.
Saves at least 75%

THE LEADITE COMPANY
Girard Trust Co. Bldg. Philadelphia, Pa.

No Caulking